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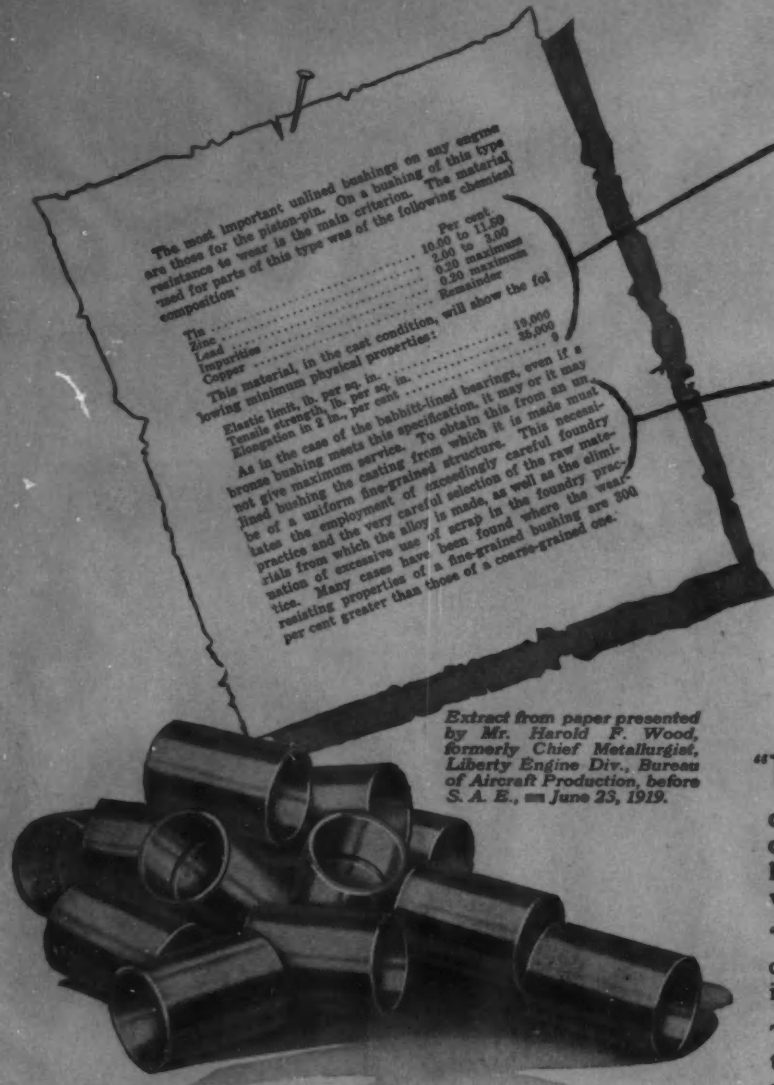

The most important unlined bushings on any engine are those for the piston-pin. On a bushing of this type resistance to wear is the main criterion. The material used for parts of this type was of the following chemical composition:

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Tin	10.00 to 11.50
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Copper	Remainder

This material, in the cast condition, will show the following minimum physical properties:

Elastic limit, lb. per sq. in.	19,000
Tensile strength, lb. per sq. in.	35,000
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As in the case of the babbitt-lined bearings, even if a bronze bushing meets this specification, it may or it may not give maximum service. To obtain this from an unlined bushing the casting from which it is made must be of a uniform fine-grained structure. This necessitates the employment of exceedingly careful foundry practice and the very careful selection of the raw materials from which the alloy is made, as well as the elimination of excessive use of scrap in the foundry practice. Many cases have been found where the wear-resisting properties of a fine-grained bushing are 300 per cent greater than those of a coarse-grained one.

Extract from paper presented by Mr. Harold F. Wood, formerly Chief Metallurgist, Liberty Engine Div., Bureau of Aircraft Production, before S. A. E., on June 23, 1919.

This Non-Gran Specification and This Non-Gran Policy

Safeguard the Quality of Every Non-Gran Bushing

"UNIFORM fine-grained structure," "careful foundry practice," "very careful selection of raw material," "elimination of excessive use of scrap"—statements made by Mr. Wood in his paper—are expressions of the policy under which Non-Gran Bearing Bronze is produced.

"Uniform fine-grained structure" is a result of the patented process under which Non-Gran is alloyed.

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HIGH SPEED
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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. V September, 1919 No. 3

S. A. E. Fostering Research Work

THE S. A. E. Research Committee appointed by the Council to give consideration to the need for research work on various automotive engineering problems including those relating to fuel, has been instrumental in bringing about two important meetings between representatives of the automotive and the fuel industries. The first of these meetings resulted in the appointment of conference committees consisting of five representatives from each industry, the purpose being to bring about closer cooperation between the two industries concerned, and in particular to arrange for a thorough study of the automotive fuel problem. A meeting was held at the University Club, New York City, on the evening of Aug. 21, the automotive industry's representatives being the hosts. John N. Willys, chairman of the committee appointed by the National Automobile Chamber of Commerce, presided. The other representatives on the automotive side were K. W. Zimmerschied, assistant to the president, General Motors Co.; Coker F. Clarkson, general manager, Society of Automotive Engineers; Alfred Reeves, general manager, National Automobile Chamber of Commerce; M. L. Heminway, general

THE DINNER OF THE REPRESENTATIVES OF THE AUTOMOTIVE AND THE FUEL INDUSTRIES AT THE UNIVERSITY CLUB, NEW YORK CITY, AUG. 21, 1919

manager, Motor and Accessory Manufacturers Association; Walter C. Baker and John G. Utz, Standard Parts Co.; F. C. Mock, Stromberg Motor Devices Co., and Herbert Chase, assistant secretary, Society of Automotive Engineers.

The petroleum industry was represented by Henry L. Doherty, Henry L. Doherty & Co., chairman of the committee appointed by the American Petroleum Institute; Dr. William M. Burton, Standard Oil Co. of Indiana; W. H. Isom, Sinclair Oil & Refining Co.; R. B. Leonard, Atlantic Refining Co.; Frank Howard and B. M. Clark, the Standard Oil Co. of New Jersey, and R. L. Welch, general secretary and C. C. Smith, assistant general secretary of the American Petroleum Institute.

Past-president Charles F. Kettering, who is the Society's official representative on the Conference Committee, had expected to be present but sailed for Europe a few hours in advance of the meeting, because of an unexpected advance in sailing date. In the absence of Mr. Kettering, a written statement which he had prepared was presented by Mr. Clarkson. This statement is printed on another page and merits the close study of all those who are seeking a solution of the fuel problem.

Mr. Kettering's statement elicited considerable very valuable discussion. Mr. Zimmerschied and other representatives of the automotive industry pointed out the need from the standpoint of this industry of securing the best possible forecast concerning the nature of fuels that will be available for use in automotive apparatus now being produced or prepared for production in order that steps can be taken to utilize this fuel efficiently and with the greatest possible degree of satisfaction to the users.

This led to a discussion of the subject of fuel specifications and it was generally agreed that fixed specifications would be detrimental to both the producer and the consumer but that more or less flexible specifications which could be changed from time to time as the exigencies of the situation with respect to fuel supply and demand may dictate, would be useful to all concerned and that if such specifications could be agreed upon to cover even a year's time with some forecast for a longer period, such an arrangement would be of great utility to the automotive manufacturer and aid greatly in enabling him to design his product so as to utilize the fuel efficiently and with the greatest degree of satisfaction possible.

It was agreed that the representatives of the automotive industry shall outline in considerable detail the various difficulties which the automotive engineer and the car user respectively face in adapting their product to and utilizing to best advantage the present-day gasoline. An endeavor will be made also to state clearly the fuel problem as it appears to the automotive industry. This will assist the fuel industry in preparations to meet the problem so far as this can be done by the refiner. The representatives of the automotive industry indicated a desire and intention to adapt the apparatus then produced to the fuel which the petroleum industry, faced on the one hand by increasing demand and on the other by diminishing supply of fuel, can produce.

It was generally agreed that the numerous problems involved in a satisfactory adjustment of the situation render thorough and extensive research necessary. There were many expressions of a desire for hearty cooperation on both sides. Resolutions providing for the maximum utilization of present laboratory apparatus and other research facilities were adopted, as was also a further resolution providing that if present facilities are not adequate for a solution of the problem in hand, ways and means for securing additional facilities of a more centralized nature and better suited for attacking the problem are to be given careful consideration. Steps are to be taken to bring the technical men of both industries into contact, and these men are assured of the hearty support of the executives through whom their recommendations will be put into effect.

Automotive Research in General

The officers of the Society, and it may be said the membership as a whole, fully realize that, although the fuel problem is doubtless the most pressing and important one which faces the automotive industry at this time, much research work on other problems is necessary and it was for the purpose of dealing with research problems of a general nature as well as with the fuel problem, that the S. A. E. Research Committee was appointed. Another object in the appointment of the committee was to provide a medium for complying with a request of the Bureau of Standards that the Society assist it in an advisory capacity in the formulation and conduct of research work in the automotive fields. The Society was asked to take an active part in the present program of automotive research at the Bureau, advising in what respect this program can be made most useful to the automotive industry as a whole.

A tentative program of work now in progress or in contemplation at the Bureau is given on a following page. Copies of this program have been forwarded through the S. A. E. Research Committee to many companies represented in the membership of the Society, with the request that it be made the subject of such comments and recommendations as seem fitting. Upward of 100 replies have been received to date. Almost without exception the program as already laid down is favored. In many cases concrete suggestions for changes in or additions to the program have been submitted. The replies are now being analyzed by the Research Committee, which welcomes further advice from members of the Society or other competent judges.

The communications received indicate the growing need of a more thorough study of the various problems relating to fuel and its proper utilization. The need for better design in carbureters and in methods of properly vaporizing the mixture and distributing it to the various cylinders is emphasized from many angles. Such items as proper metering and atomization of the fuel, methods of heating the mixture and the like are discussed with varying degrees of emphasis. Other replies lay stress upon the need of further study of the basic phenomena of combustion, some taking the view that the fuel problem will not be solved until much basic research into combustion phenomena has been carried forward, and these phenomena become better understood. Others point out the necessity for study of the best compression ratios, the effect of water injection and for researches intended to determine the cause of the "knock" in engines. One member has reached the conclusion that refinery practice can in many cases be controlled so as to avoid the production of fuels which give rise to the "knock."

Several members discuss the demand for further investigation into the possibility of utilizing alcohol or mixed fuels containing two or more such ingredients

as alcohol, benzol, kerosene and the like. Others express the belief that the constant-volume engines now so generally used are not as well suited to automotive purposes as those working on other cycles. The use of constant-pressure, Diesel and even steam engines is mentioned as worthy of careful study. The possibilities of air-cooling some think will be further investigated. The need for better methods of measuring instantaneous temperatures and pressures as related to many varieties of research is emphasized.

Lubrication is mentioned by many as a subject of importance second only to that of fuel. Some urge the standardization of lubricating oil specifications, while others state that prior to doing this the general laws of lubrication must be better defined. The subject of allowable bearing pressures, questions relating to viscosity, crankcase dilution and the decomposition of lubricants under the effect of heat all demand much study. One engineer draws attention to the fact that the relative merits of asphaltum, mid-continent and paraffine base lubricants have never been settled.

Several members emphasize the necessity for research on the subject of springs and spring suspension, it being generally agreed that there is much room for improvement in the springing of present-day automobiles. It appears that the laws governing the correct design of springs and their effect upon the riding qualities of the car to which they are applied, if known, are not well understood.

Many have expressed a desire to have further research work prosecuted in the matter of determining what kind and quality of tires are best suited for various purposes. The different items mentioned as requiring study in this connection include the effect of internal friction in tires upon their life, the bearing of frictional losses in tires upon gasoline consumption, or, in the case of electric cars, on the consumption of electrical energy, the relative effect of wood and steel wheels on tire life, the relative effect of the use of solid and pneumatic tires on the durability and future construction of the chassis and the effect of various types of fabric on the life and efficiency of tires.

Members interested in electrical equipment for automobiles from both the producers' and users' standpoint mentioned the desirability of further investigation into the relative merits of the various types of electrical apparatus such as batteries, magnetos, starting motors and lighting generators. Some details mentioned in this connection included specifications for ignition cables, carbon brushes and storage battery parts, and factors having a bearing upon the starting of engines in cold weather.

A plea for a thorough study of the cooling systems used on various types of automotive vehicle was contained in several communications. Some of the items specified included the size and capacity of pumps, water-jackets, radiators, fans and other portions of the cooling system. Stress was put on the desirability of determining the most efficient operating temperatures and ways and means for maintaining such temperatures. One engineer mentioned the need for further investigation to bring about the development of non-corrosive and otherwise thoroughly satisfactory anti-freezing compounds.

Some members laid special emphasis upon the need for further information in regard to brake linings, with reference particularly to durability, the effect of heat and the determination of the coefficient of friction under various conditions. Among other matters urged for consideration were research into factors governing the basic design of such members as the crankshaft, including especially the cause and effect of transverse and torsional vibrations and means for eliminating these and the effect of bearing location upon vibration phenomena. Still another problem suggested was that of the development of a suitable dust-filtering device or medium.

Of particular interest should be the suggestion of one engineer who states that there is great need of developing a method for locating hidden flaws in metal which cannot be found even by the most careful inspection system now employed. Such a method if found and commercially developed would have an important bearing upon the production of many metal parts. Thus in the particular case cited the factor of safety utilized might be greatly reduced if it were not necessary to allow for hidden flaws.

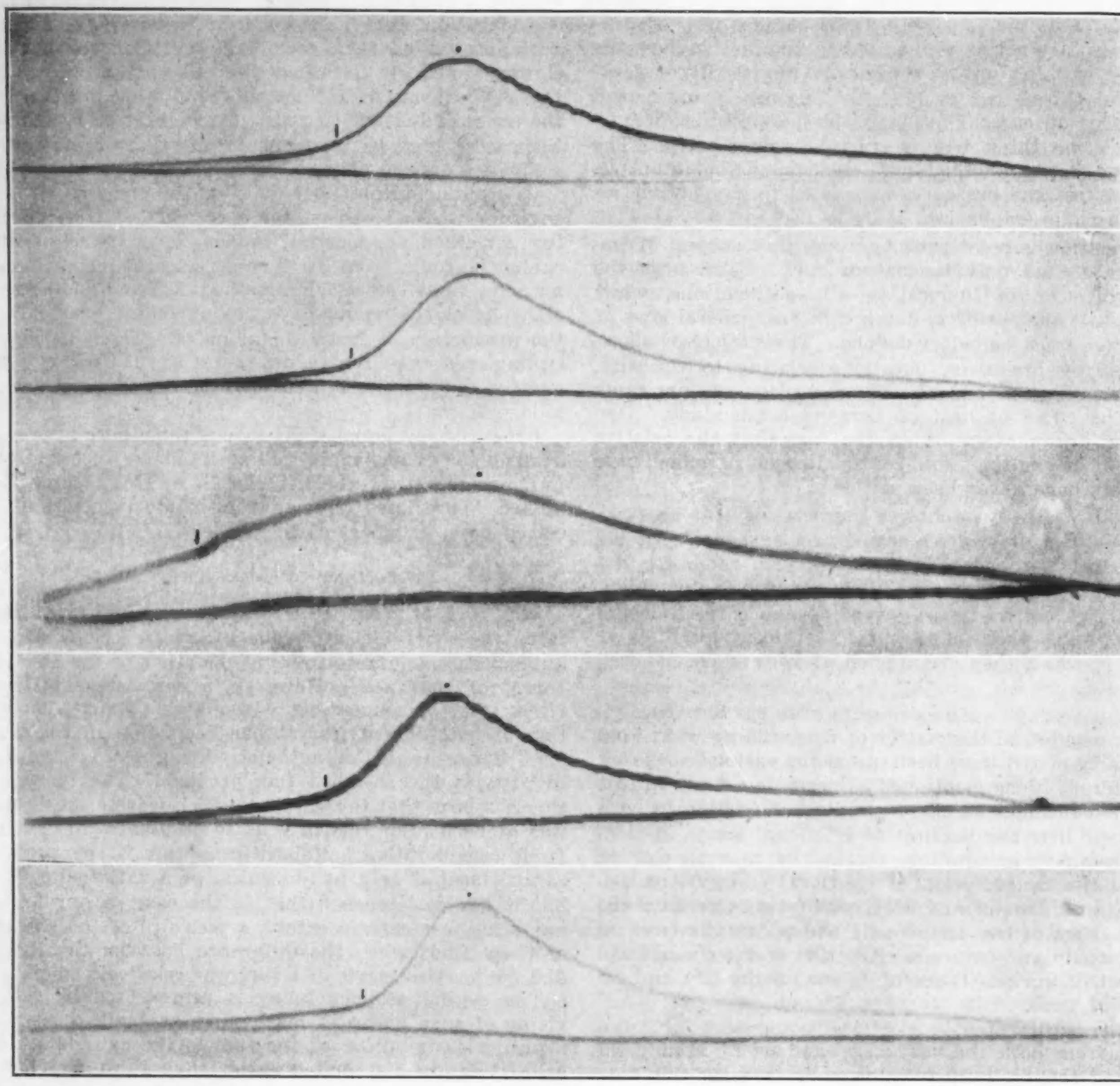
From the foregoing it is obvious that there is pressing demand for extensive as well as intensive research work in many automotive fields. The S. A. E. Research Committee appreciates greatly the many suggestions received from members of the Society.

Statement of Mr. Kettering

The fuel problem, as it exists today, divides itself into two general classes, one of which belongs to the automotive manufacturers and the other to the manufacturers of the fuels. However, a complete solution in either case is impossible without the hearty cooperation of both industries. It has been only in the last 2 or 3 years that the automotive engineers have been faced with the so-called fuel problem. The reason for this has been that the gasoline which was formerly used, was of such high volatility as to eliminate this entirely from consideration. Volatility is not to be regarded as an essential or a non-essential of a satisfactory fuel, but it has so happened that in the case of our fuels it has been, to a certain extent, a measure of the efficiency of these fuels when the difference between the lightest and the heaviest parts of a fuel was relatively small.

The engine problem today is represented by the devising of such pieces of mechanism as are necessary for a proper distribution of the fuel to the cylinders. Volatile fuels are distributed easier than those which have to be atomized. In addition to this the engine builders can put in additional temperature controls for holding the temperatures of both the air and the cylinder walls within closer limits. When all of these things have been done we still fall short of getting the results that should be expected, were this problem purely one of the mechanical treatment of the fuel and mixture.

The internal-combustion engine is essentially a chemical device, and, unless we begin to analyze the changes which take place after the fuel starts to burn in the cylinders, we shall be disappointed in the result obtained after the things mentioned previously have been done. The one important thing in lower gravity fuels is the fact that they give rise to the phenomenon commonly known as the "knock", variously understood to be "prematuring", and supposed to be brought about by the deposition of carbon in the combustion chamber. It has been conclusively demonstrated and repeatedly checked, that the "knock" which occurs in an engine and is supposed to be due to carbon, is not caused by preignition but is produced by the nature of the combustion which in turn is controlled entirely by the molecular structure of the fuel. It is a well-known fact that grav-



INDICATOR CARDS TAKEN FROM DELCO-LIGHT ENGINE USING

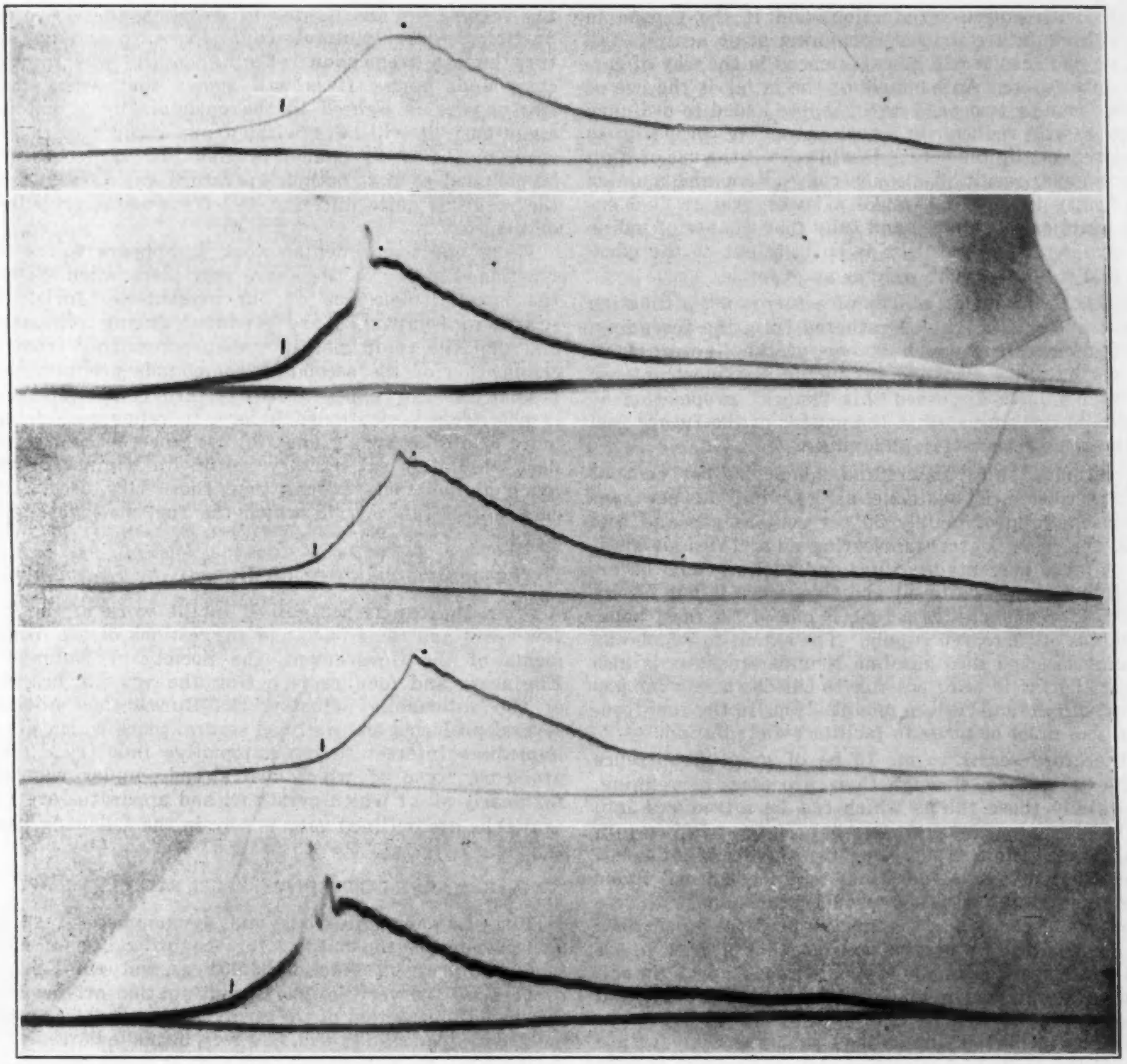
In each c se the vertical dash indicates the point of ignition and the dot the top dead center. The lines. The cards are made on a uniform time base and are not therefore directly comparable with the arranged in the same order

Alcohol—This card shows no very rapid rise in pressure, with consequent smooth operation.
Benzol—This fuel possesses pressure-producing characteristics similar to alcohol.
Carbon Bisulphide—Note the very early "pre-ignition *without* and consequent "knock" or rapid pressure rise, showing conclusively that "knock" is *not* caused by "pre-ignition", as has often been supposed.
Commercial Gasoline—No evidence of "knock".
"High Test" Gasoline—Pressure rise is rapid, but there is no indication of "knock", further indicating that "knock-producing" quality is independent of either gravity or volatility of fuel.

ity is in no wise a measure of this knocking phenomena, as oils from the California crudes of very low gravity, one familarly known as "Twenty-seven Plus Fuel Oil," gives a great deal better satisfaction than a 50 gravity oil refined from Pennsylvania crudes. The reason for this is that in the California crudes there is a large percentage, roughly 40, of the so-called cyclic compounds.

A great deal of work has been done under my supervision in the last 3 or 4 years in the determination of what takes place when the heavier fuels burn in a cylinder, and a few conclusions have been arrived at, which may be briefly expressed as follows:

With lower gravity fuels it has been necessary to lower the compression. Lowering the compression, in turn, has facilitated the formation of carbon, and carbon, in turn, has aggravated the "knock." The reason is simply this. Increasing compression results in higher instantaneous temperatures, and the high instantaneous temperatures result in a type of combustion which makes possible an exceedingly rapid rise in pressure, this rise being of very short duration. Lowering the compression gets away from this, with the result that if the engine is running at low throttle, a precipitation of carbon in the combustion chamber is caused. This deposited carbon forms the best possible type of heat



VARIOUS FUELS. 50-LB. COMPRESSION PRESSURE

compression line begins at left end of card and is followed successively by combustion and expansion usual pressure volume diagram. The following explanatory paragraphs for the different fuels are as the reproductions of the cards.

"Hecter" 70 per cent Cyclohexane and 30 per cent Benzol—Note the flat combustion line without any very sudden rise in pressure. This is conducive to a very smoothly operating engine.

Kerosene—Note peak indicating sudden rise in pressure and causing "knock". The latter is *not* caused by "pre-ignition".

3½ per cent Aniline and 96½ per cent Kerosene—Addition of aniline has nearly eliminated the pressure peak and consequent knock.

5 per cent Ethyl Iodide and 95 per cent Kerosene—The peak and the consequent "knock" are substantially eliminated by the use of ethyl iodide.

25 per cent Sulphuric Ether and 75 per cent Kerosene—Note that addition of a considerable percentage of a highly volatile liquid, sulphuric ether, has accentuated the peak and the consequent "knock", showing that volatility of fuel is not a measure of its "knock-producing" characteristic.

insulator and again permits the temperatures of combustion to rise above the critical point which had been eliminated by reducing the compression.

This discussion is mentioned here for the simple purpose of showing that lowering compression is only a temporary remedy. Lowering compressions and increasing cylinder bore only decrease the efficiency of the engine and as long as the fuel burns so as to produce these abnormally high pressures, we will have the "knock" trouble sooner or later.

It has been proved positively that certain things can be added to the fuel which would not necessarily increase its gravity but which render the engine free from "knocks." These additions to the fuel can roughly be divided into two classes, the high percentage class and the low percentage class. By high percentage class we mean from 20 to 40 per cent and by low percentage class we mean from ½ to 3 per cent. An example of the former is an introduction of benzol. Forty per cent benzol mixed with ordinary commercial kerosene makes an engine

operate with entire satisfaction, and if the engine in which this mixture is used is running at or near its full load, no bad results will be experienced in the way of carbon deposits, etc. An example of the latter is the use of iodine. One or two per cent of iodine added to ordinary kerosene will reduce its knock-producing property to an entirely negligible point. It will permit the use of high compressions, result in cleaner combustion and, outside of difficulty in starting, make a lower gravity fuel entirely practical. I understand fully that the use of iodine as a commercial proposition is entirely out of the question, and it is cited here only as an example.

The knock-producing ability of a fuel is not a function of its gravity, as might be gathered from the foregoing, as sulphuric ether, which is one of the lightest fuels that we have, is also one producing the most intense "knock." I have discussed this "knock" proposition as a preliminary thing so that the matter of the future fuel supplies might be better understood.

As oil men fully understand, about 20 per cent of crude petroleum is available as gasoline, 12 per cent as kerosene, approximately 50 per cent as gas and fuel oil and the remainder as lubricating oil and residue products. A large percentage of gas and fuel oil could be refined into a water-white oil and this, were it not for its "knocking" tendencies as a fuel, is one of the most hopeful sources of increased supply. The extent to which oils are being cracked into gasoline is understood, as is also the fact that, if it were possible to cut down into the gas and fuel-oil section, certain modifications in the fuel-feeding devices must be made to facilitate distribution.

It therefore seems to me to be of great importance that the oil people, through their processes of refining, should study those things which can be introduced into a fuel to prevent such rapid rises in pressure when certain of the lower gravity fuels are burned. It might be of interest to know that a fuel which will not "knock" under normal conditions will not produce an abnormal rise in pressure, even though the fuel be fired far in advance of the normal point of ignition, so that a fuel which would not "knock" normally will not "knock", even though the engine be heated to the point at which pre-ignition will occur.

It is also definitely understood that the temperature of the cooling water in an engine may or may not greatly affect the temperature of the explosive mixture during the process of combustion, as the thickness of cylinder walls, condition of carbon inside of the cylinders, etc., may be such that the engine, from external appearances, will be running perfectly cool, and yet the conditions inside the cylinders will be such as to bring the temperature of the mixture during combustion above the critical point at which the "knock" occurs. It looks to me as though one of the fundamental problems involved in this is a study of the chemistry of the products formed during the process of combustion. As these are in no wise simple reactions, they are rather difficult to determine and experiments intended to discover their nature must be made in a more or less empirical way.

An illustration of the type of combustion which takes place is this: If a piece of celluloid be ignited by a cigar, it will entirely decompose without the formation of any flame; if lighted by a match, the phenomenon of inflammability will at once be shown. The celluloid itself is not inflammable, but the gas formed by the decomposition of the celluloid is extremely so. When the celluloid is ignited by a cigar butt the temperature does not rise high enough to cause inflammation of the vapors which are formed. When lighted by a match, these two combustions occur simultaneously. Pressure and temperature have a tremendous effect upon the way in which compounds burn. It is well known that when smokeless powder is lighted in the open air by a match or cigar butt, it will burn without any rapid rise in pressure, but if the products of this primary combustion be confined so that both temperature and pressure rise, the result is quite different and tremendous pressure is developed.

From our experimental work it appears to us that reactions similar to the above take place when we burn the heavier molecules of our present-day fuels, that secondary compounds are produced during combustion and that the rapid rise in pressure resulting from the combustion of the secondary compounds produces what is known as the "knock". It is my firm conviction that it is possible, as mentioned before, to refine considerably more of our present crudes into engine fuel and to produce absolutely satisfactory results in engines of very much higher compressions than those now used, if we can control the way in which the fuel molecules break down.

Tentative Program of Bureau of Standards

From the experience gained in the work of the past few years and the advice and suggestions of the departments of the Government, the Society of Automotive Engineers and men representing the various branches of the automobile industry, the Bureau has initiated several problems and outlined several more which are of immediate interest to the automotive industry. These problems, some of which are already under way and for nearly all of which personnel and apparatus are now available, are outlined very briefly in the following paragraphs.

KEROSENE CARBURETERS, "FUEL SAVERS," ETC.

Laboratory examinations and dynamometer tests of devices now on the market for the utilization of kerosene and poor gasolines, fuel savers and gasoline improvers will be very largely a continuation of those for the inventions section of the Army and the Navy Consulting Board. The results will, however, be made immediately available to the automotive industry at large and should be very valuable in solving the problems of adapting the engines now in use to the changing character of the fuels available. The nature of this problem will make it necessary to investigate the difficulties encountered in the operation of engines with kerosene, and interesting results are to be expected.

LUBRICATION

The investigation started for the War Department has made equipment and personnel available for the solution of many of the perplexing problems of lubrication confronting the automobile industry. Such are the dilution of crankcase oil, the physical and chemical properties of oils suitable for use in automobile engines, the possibility of the regeneration of used oils, etc. It is hoped to obtain valuable information on these questions.

AUTOMOBILE AND TRUCK PERFORMANCE

The Motor Transport Corps has shown great interest in the automobile dynamometer now being constructed at the Bureau. It is felt that there is a great need for more information on the power losses incurred in the present

designs of automobiles and motor trucks. The knowledge gained through work with a car dynamometer will enable an attack of the fuel shortage problem from the car design standpoint.

CARBURETER DESIGN

The design of carbureters is dependent upon knowledge of the requirements of engines for economical fuel utilization. The apparatus and methods for the study of these requirements are available at the Bureau of Standards, and in view of the importance of fuel economy it is felt that they should be made available to the whole automotive industry as soon as possible. The apparatus designed for the testing of airplane carbureters is being made available to manufacturers for the study of the performance of their products.

COMBUSTION OF HYDROCARBON FUELS AT HIGH PRESSURE

There is need for a knowledge of the fundamental chemical and physical phenomena occurring in the combustion of hydrocarbon fuels. This work should be of great value in overcoming the difficulties encountered in the operation of engines on kerosene and heavier fuels. The chemical and physical laboratory equipment is available for this work. In this connection a method has been developed for the measurement of the rate of flame propagation in an engine in operation, and a high-speed indicator has also been designed which gives great promise of success.

SOLID AND PNEUMATIC TIRES

There has been designed and constructed a tire-testing dynamometer, and by utilizing this equipment in connection with the car dynamometer, it is hoped to obtain very valuable information as to tire design and construction. An investigation has been planned of the effect of accelerators and compounded ingredients upon the physical properties of rubber and its rate of deterioration. It is hoped to discover a satisfactory accelerated aging test which will indicate the probable life of the sample under ordinary conditions of use. Investigations are also being carried on with a view to the improvement of the present methods for reclaiming rubber.

The work outlined above is that contemplated for the immediate future. It should be understood, however, that this program is tentative only and subject to change, should problems more important to the industry present themselves. The Bureau believes, however, that this work should be continued, and as financial support has been provided by Congress for the continuation of only a very small part of the work, estimates have been prepared for consideration by Congress in connection with the fourth Deficiency Bill, outlining the necessity for at least $75,000 additional for its continuance.

During the war the Bureau has been able to render much valuable aid to the military departments of the Government through very close cooperation so that scientific and technical problems were presented to the Bureau as they arose. The Bureau believes that it should render a similar service to the automotive industry of the country and that a similar close cooperation between the automotive industry and the Bureau should be established.

COOPERATION WITH THE ORDNANCE DEPARTMENT

As indicated by General C. C. Williams, chief of ordnance of the United States Army, in his remarks at the Ottawa Beach Meeting of the Society, plans for further affiliation with the Ordnance Department have been under advisement by the Council for some time. The Society has been requested to appoint a committee to cooperate with the Ordnance Department in the carrying out of recommendations of the Board of Officers on motorization of field artillery. The Council recently appointed the following as members of a general committee for this purpose: H. W. Alden, chairman; W. G. Wall, Dent Parrett, C. F. Kettering and G. W. Dunham.

Some alternate members, including J. G. Vincent, have been appointed, and it is the intention that members of the Society who are specialists in various lines of automotive work will be asked to advise the committee from time to time.

The committee will hold a session in Washington during the month.

General Williams has stated that a permanent exhibit will be maintained at the Rock Island Arsenal of all automotive apparatus used by the Ordnance Department, and that, in accord with his desire that the best talent of the industry shall be applied to the improvement of present and the development of new automotive apparatus for field artillery work, the members of the Society will be welcome there at any time for such inspection and investigation as they may care to make.

USES OF HIGHWAYS

In an effort to include probable future military needs and uses for roads to be constructed under the provision of the Federal Aid Road Act, a conference of road experts was recently held in the office of the Secretary of Agriculture. An itemized summary of the war material that will be required for improving highways under the provisions of this act has been prepared by the Secretary and presented to Congress. Further steps will be taken to provide all the required material as far as it is practicable to do so from the surplus Army equipment.

Heavy-Fuel Carbureter Type Engines for Vehicles

By J. H. HUNT[1] (*Member*)

METROPOLITAN SECTION PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

RISING fuel prices in the face of an approaching shortage of fuels suitable for the present type of motor-car engine have led to considerable experimental work with kerosene and lower grade petroleum distillates with the idea of using them to supplement the supply of gasoline. Many of these attempts have been made with kerosene or distillates having no lighter fractions. This work has been prompted by the present discrepancy in the selling price of gasoline and kerosene, a difference which will certainly vanish as soon as there are any appreciable number of motor-car engines equipped to handle the lower grade fuel. There has also been considerable work with fuels obtained by mixing a certain percentage of heavier fuels with ordinary or casinghead gasolines. Most of this latter work has been done by the fuel manufacturers. They have carried out experiments of enormous extent in an effort to find how much of the heavier fuels can be used in an engine of ordinary design. They have made and sold the fuels, and the user has carried out the road tests. Manufacturers of carbureters and ignition devices have been called upon to help in overcoming troubles caused primarily by the introduction of too many heavy fractions into automobile fuels. There has also been a limited amount of laboratory work with fuels consisting of cuts taken from the heaviest fractions that it is considered possible to use, through and including the lighter fractions called gasoline 10 years ago.

As far as completely satisfactory running is concerned, the difficulty of the problem is determined by the heaviest fraction present in an appreciable quantity. This statement applies to straight petroleum distillates. For the purpose of this paper the only fuels under consideration are straight petroleum distillates which have not been subjected to any cracking process and to which no other materials have been added. When lighter fuels are present in quantity it is possible to obtain deceiving results and secure what seems to be fair operation for a time, the fact that the result is not the final solution not becoming evident until the condition of the engine is examined after a service test of some length.

The problems connected directly with the use of heavier fuels may be classified as starting, carburetion, distribution and combustion.

STARTING

If starting is defined as the complete process of getting the engine into a condition where it is satisfactorily flexible and operating with its normal economy, it is obvious that much more is involved than simply obtaining a few explosions. The engine is really started only after all parts are at the same temperature conditions that exist in normal running and when it responds to the accelerator in the normal manner.

With fuels containing a fair percentage of light hydrocarbons like our present gasoline, getting a few explosions is fairly simple even in cold weather. All that is necessary is to provide a good "choking" device aided by a "priming" device, if the inlet manifolds are long and of exceptionally large area, or if the lift is great. An excessive amount of fuel is supplied of which only a small part is vaporized to produce an explosive mixture. Much of the remainder is deposited on the walls of the combustion chamber where it is cracked by the heat of the explosion, forming tarry carbon deposits, or it flows by the piston-rings into the crankcase, cutting the oil off the cylinder walls, polluting the crankcase oil and reducing its lubricating qualities. The inevitable result is excessive wear of piston-rings, cylinder walls and bearings in cold weather service. As a result of the poor fit of the rings the products of combustion leak by during the explosion and the working stroke. The vapor formed by the burning of the hydrogen in the fuel condenses in the crankcase. The water freezes whenever the temperature of the crankcase falls low enough, with the result of broken oil-pump drives or obstruction of the oil supply and sticking of the engine if it is driven before the ice has time to thaw.

The addition of more heavy hydrocarbons to our present fuel will simply increase these troubles with our present type of engine. The longer an engine takes in reaching its final operating temperature, the worse these difficulties become. Anything that can be done to accelerate the warming up of the engine will tend to reduce them and the present prevalence of thermostatic controls on the water circulation, radiator shutters, etc., shows the increasing appreciation of this fact on the part of the manufacturer. In spite of all that has been done to date, the situation with even the present grade of fuel is not satisfactory in cold weather. It is no unusual thing to remove from the crankcase of an automobile after only a few hundred miles service, a mixture which on distillation gives from 30 to 60 per cent of hydrocarbons that belong in kerosene or gasoline and not in the lubricating oil, and where excessive priming occurs it is quite possible to have a mixture in the crankcase which will give off explosive vapors when the engine heats up. If the fit of a set of rings is so bad that the flame gets by during the explosion, a wrecked engine results. The ordinary driver today is a sufficiently good judge of car performance to insist on repairs before this condition arises; nevertheless, one hears rumors of occasional crankcase explosions.

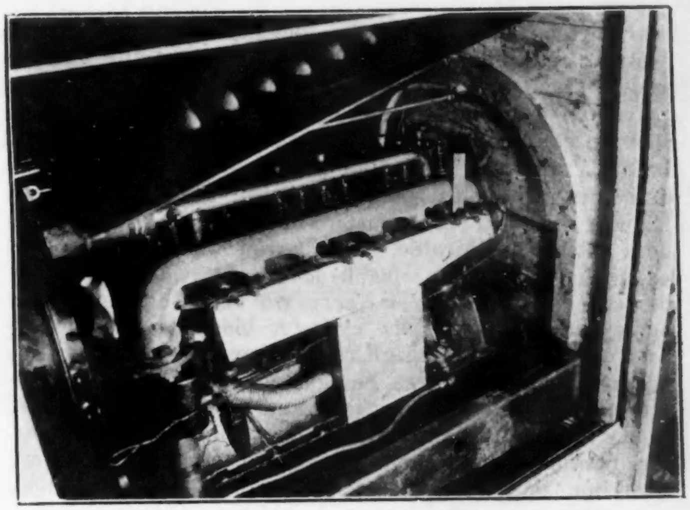
The only complete remedy for this condition would be to bring the engine before cranking into a condition such that it would start and run with perfect distribution without any choking or priming attachment whatever. The only way to accomplish this would be to bring the temperature of all parts of the carbureter, inlet manifold and cylinder walls to the final operating temperature before cranking or at least before using a heavy fuel.

[1]Research engineer, Dayton Engineering Laboratories Co., Dayton, Ohio.

There are two possible methods of getting the engine to the proper condition for running. One is to employ a two-fuel carbureter, using a very volatile fuel to start and warm up the engine. This gives perfectly satisfactory results as far as the engine is concerned. There are several disadvantages in the use of two fuels. The first is the nuisance of keeping two fuel tanks filled. The second is the difficulty of keeping a float valve, which is subjected to vibration on the road, tight. The ordinary float valve is not tight under these conditions, but as the slight amount of leakage is removed by the normal action of the carbureter we do not recognize the leakage. There is also a possibility of some loss of the light fuel by evaporation due to the effect of engine heat.

The other method of starting is to heat the engine before cranking by a burner designed to use the heavier fuel. As far as the carbureter and manifold are concerned it has been demonstrated that this is fairly easy as burners have been developed which will deliver 40,000 to 60,000 B.t.u. per hr., a rate which is sufficient to heat a heavy cast-iron manifold in less than 2 min. in zero weather to the point where starting is possible without any choking or priming, and if the manifold is made of thin welded steel, or better, of aluminum, good running conditions are obtained in 20 sec. These burners use an airblast from a motor-driven fan and are electrically ignited by a spark-plug. They can thus be controlled by a simple switch on the dashboard.

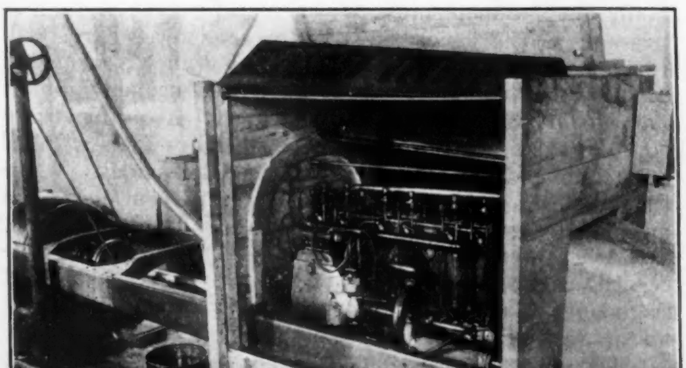
Some tests were carried out just before our entry into the war, which will suffice to give some idea of the conditions existing with our present fuels. A six-cylinder engine, having practically the entire distribution system external to the cylinder block, was selected for test as it permitted easy modification of the distribution system. The manifold first used was not equipped with any provision for heating, although both the throat of the carbureter and the incoming air were heated. The engine was mounted in a frame with a radiator in the normal position and refrigerated air was blown through the radiator. The arrangement is shown in one of the accompanying illustrations. A series of thirty-six tests was made by cranking the engine when the incoming air was at 0 deg. fahr. and when the radiator water was from 20 to 32 deg. fahr., representing conditions occurring when the engine has been standing for some time in zero weather. The standard equipment was used as far as carburetion and distribution were concerned. After



Heating the Carbureter of an Internal-Combustion Engine to Eliminate Choking at Start

starting it was necessary to use the choker for a considerable period to keep the engine running. The engine was run at about 600 r. p. m. with a load of from 3 to 4 hp., corresponding to driving within the traffic laws on a cold day on good pavement. It was occasionally slowed down to about 300 r. p. m. and the throttle opened. When the engine had warmed to the point where it would accelerate without the use of the choker and without missing, the test was discontinued. The test runs were about 15 min. long. From time to time during the test samples of the crankcase oil were removed for distillation tests. The percentage of hydrocarbons belonging in kerosene and gasoline which distilled off below 450 deg. steadily increased and amounted to about 63 per cent at the end of the thirty-six starts. Fresh oil was put in and a run of an equivalent length of time, that is for 9 hr., was made at a constant speed of 600 r. p. m. and with the same load as before, the engine being cranked only twice in this time. At the end of the running it was found that there had been no increase in the lighter hydrocarbons. About 400 cu. ft. of air, cooled down to zero, was being blown through the radiator each minute of the test run.

The inlet header was then provided with a sheet metal jacket, being arranged so that the carbureter also was heated. An electrically heated burner was fitted to this jacket and mounted at the rear of the dashboard, the arrangement of the jacket being as shown. The burner was run long enough before each test so that the engine would start without any choking. A series of thirty-six starts and runs of about 15 min. each was made as before. In the tests the lighter hydrocarbons in the crankcase increased about 23 per cent. As no provision was made for maintaining the temperature of the inlet header after starting it soon cooled down to where the distribution was unsatisfactory under the test conditions. Another series of tests was then made in which the burner was kept running long enough after cranking so that no evidence of faulty distribution serious enough to cause missing developed during the 15-min. run. Under these conditions the increase in light hydrocarbons during the thirty-six starts and runs was reduced to about 13 per cent.



Test Arrangement for Blowing Refrigerated Air Through the Radiator of an Internal-Combustion Engine to Simulate Winter Conditions

It is my opinion that the crankcase pollution met with in the last test was due to the fact that the cylinder walls were entirely too cold in the early part of this run. In fact, they were never hot enough as no radiator shutters

were fitted and there was no thermostatic control of the water circulation. The cold air was blown through the radiator and over the engine all the time. All crankcase pollution, therefore, cannot be removed unless the combustion chamber and cylinder walls are properly heated before cranking. This will require very large burners or a much lower thermal capacity of the cylinder block than at present or a compromise. A larger burner alone does not seem desirable. The burner will either be very expensive or an undesirable length of time will be required. The difficulty is increased because means must be provided whereby the cylinder block can absorb the heat efficiently at the high rate required. The conditions discussed will, of course, be aggravated by increasing the percentage of heavy fractions and any engine designed to use heavier fuels than at present will require preheating by one or the other of the two possible means before cranking, or serious lubrication troubles will develop, particularly in cold weather.

In part of the experimental work, a modification of the burner described in the paper[2] entitled, "Kerosene versus Gasoline in Standard Automobile Engines," which was presented by Dr. C. E. Lucke at the 1916 Semi-Annual Meeting of the Society, as part of the Good kerosene equipment was used. The motor-driven fan supplies air at 9 to 12 in. water pressure to the chamber *a*. Some of this air passes through the opening *b*, atomizing the fuel issuing from the nozzle *c*. The fuel is forced from the chamber *d* by the air under pressure which comes through the hole *e*, that is provided with an adjusting screw *f*. The combined action of the vent hole *g* and the restriction caused by the screw *f* permit any desired fraction of the pressure in the chamber *a* to be effective on the fuel in *d*. The atomized fuel from *c* is ignited by the spark-plug at *h* and mixed with the proper amount of air through the openings at the right in the central casting *i*. Apparently practically perfect combustion is obtained, either kerosene or gasoline being used as a fuel.

How the burner was applied to the distributing system of a six-cylinder marine gasoline engine is shown diagrammatically. In this case an exhaust gas-heated venturi vaporizer was combined with the burner installation. A very great improvement in starting conditions in winter weather was noticed. The application of the starting burner to a six-cylinder automobile engine, a special cast inlet manifold being fitted to permit the burner installation, is also illustrated. With this installation the car has been run all winter in Ohio without using the choker.

Carburetion and Distribution

The problems of carburetion and distribution can hardly be separated as it is possible to go a considerable distance on the road toward securing good distribution in the carbureting device, and on the other hand, an ordinary gasoline carbureter may be used with possibly slight modifications in the jet and in the idling device, if the distributing system is properly designed. If carburetion is defined simply as the metering of the fuel into the incoming air in the proper proportions for all ranges of speed and load, including the conditions where these are changing rapidly, there is really no great difficulty involved with fuels no heavier than the present-day kerosene. As the heavier fuels have a higher viscosity than gasoline, it is undoubtedly necessary to arrange conditions so that the temperature of the carbureter is practically independent of the weather. There have been a great many attempts in the past to handle the heavier fuels in the carbureting device alone, usually with the aid of heat from the exhaust. So much heat, however, is required that it is not possible to transfer it from the exhaust to the incoming mixture in the carbureter without making this entirely too bulky. The present indication is that it will be better to have that part of the equipment which has most to do with the vaporization of the mixture built into that part of the engine usually manufactured by the engine builders rather than to attempt to incorporate it in the carbureter.

Assuming that the fuel has been properly metered into the incoming air, the problem of handling it so that it will be distributed to the cylinders by some means which will not cause too great a loss in volumetric efficiency is one of the two real problems involved in the use of the heavy fuels. The other problem is the proper control of the combustion, once the mixture is in the cylinder. Past experience has shown that it is comparatively easy to distribute the mixture when the fuel is perfectly vaporized. It is therefore natural that considerable effort has been applied to devices which produce a dry mixture with heavy fuels and then maintain this mixture hot enough through the remaining part of the inlet manifold so that no condensation can occur. Two losses in volumetric efficiency are involved in this process. The first is due to the increased temperature of the mixture and the resulting smaller charge in the combustion chamber; the second is caused by the need of considerable suction to draw the mixture through the restriction caused by the heating device. The heating surfaces must be of considerable area to transmit the amount of heat required. Part of the problem, of course, is the collection of this heat from the exhaust. To keep the surfaces from being entirely too large the mixture must be drawn by them at high velocity, resulting in great friction losses. In order to make these surfaces effective at comparatively light load and speed, the designs are usually such that the suction head required to draw the mixture through at high speed involves very serious losses in volumetric efficiency. Some of the devices now developed maintain very uniform temperatures of the mixture at varying loads and speeds but many permit too great an increase with load. This results in still further losses in volumetric efficiency at high speeds.

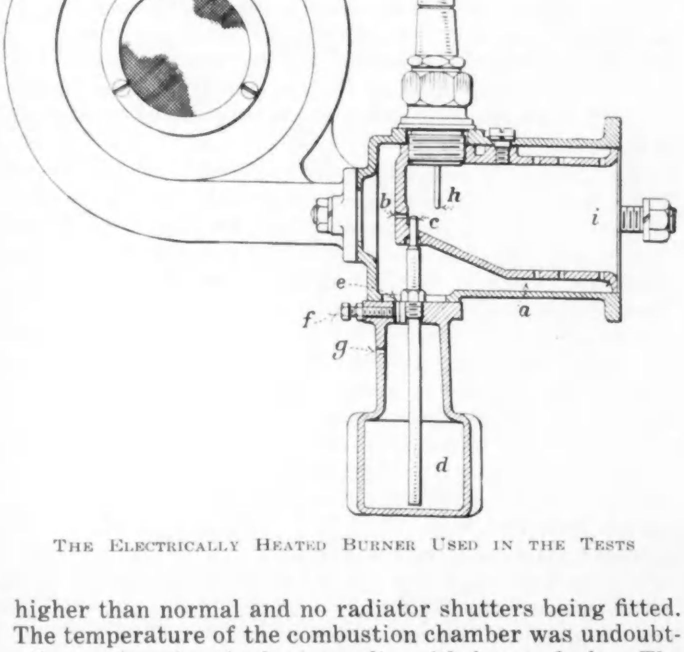
The inevitable result is to cause the engine not only to have a reduced torque at all speeds but to reach the peak of its power curve at much lower speeds than normal. If the same car performance is to be obtained the piston displacement must be considerably greater than at present, as the low peak speed of the power curve will require a change in the gear ratio. The increased piston displacement would result in decreased economy under normal driving conditions. Means of avoiding these troubles are needed if we are to use heavier fuels without a very undesirable increase in engine dimensions. There is no doubt, however, that a very large percentage of the automobile users probably would be well satisfied with cars whose performance, as far as ultimate speed is concerned, is much below that of the average car supplied today, providing, of course, that satisfactory flexibility and power were available at speeds below 40 miles per hr.

The Good venturi vaporizer, which Dr. Lucke described in the paper previously referred to, has, in addition to the bench testing, had a very considerable amount of service work on the road which indicated that the cars of drivers who would be satisfied with a comparatively moderate maximum speed could be taken care of in the immediate future. One of these equipments has been in

[2]Printed in the *S. A. E. Bulletin*, June, 1916.

service for about 2½ yr. on a Ford engine, during which time the car has been run 20,000 miles in all kinds of weather. In the first 2 yr. there was no mechanical trouble with the engine whatever. It has been found necessary to change the oil in the crankcase more frequently than if gasoline were being used. It has also been necessary to clean out the carbon more frequently than in the case of the average engine using gasoline. In general, however, the service of the engine might be considered very satisfactory.

A Buick D-45 six-cylinder car has been equipped with such a device and run a little over 10,000 miles in a period of about 14 months, including the larger part of two winters. No mechanical trouble developed in this engine at all. About half the crankcase oil was removed every 1000 miles and fresh oil added. Both of these cars were run as single-fuel cars, the manifolds being preheated by a burner preparatory to starting. Both cars were run with the standard equipment except for the vaporizer and the burner, no provision being made to control the temperature in the radiator to any value



THE ELECTRICALLY HEATED BURNER USED IN THE TESTS

higher than normal and no radiator shutters being fitted. The temperature of the combustion chamber was undoubtedly too low for the best results with heavy fuels. The compression was reduced in both engines to avoid excessive knocking.

There has also been a great deal of development work on devices where only part of the air is heated with the fuel to a point above vaporizing temperatures, colder air being added later. It is probable, however, in most of these as now installed that a really dry mixture is not secured but a sort of fog when the colder air is added for tempering the overheated, over-rich mixture. I have had no opportunity to test such devices on engines that could be called high speed. It seems probable, however, that at high speeds distribution troubles would be encountered unless the manifolds were very carefully designed. It will perhaps not be out of place to mention in passing that where the attempt is made to handle

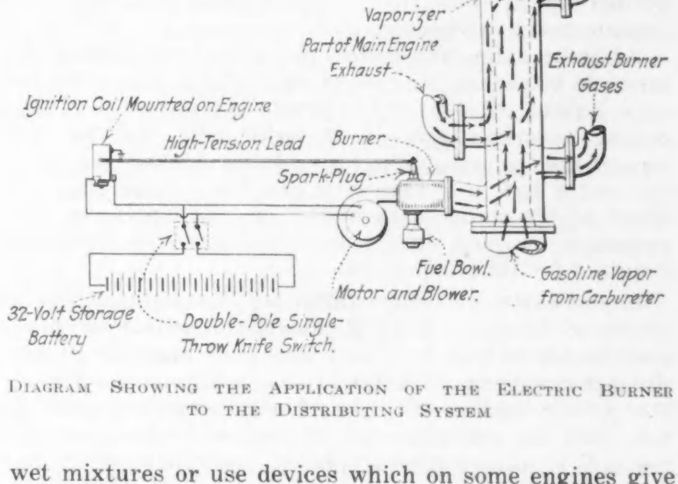
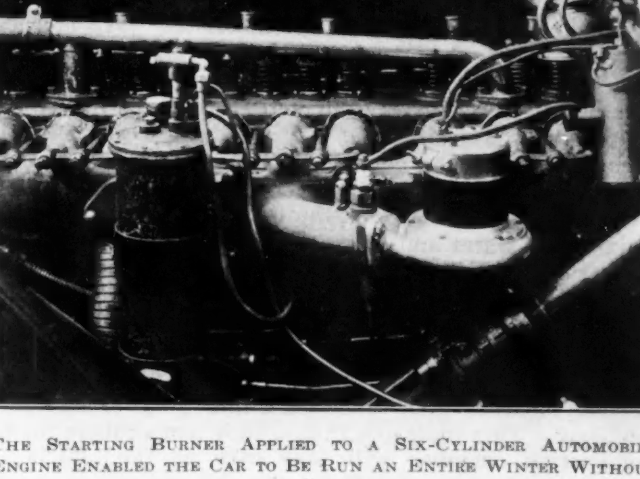


DIAGRAM SHOWING THE APPLICATION OF THE ELECTRIC BURNER TO THE DISTRIBUTING SYSTEM

wet mixtures or use devices which on some engines give dry mixtures, the data available are not yet sufficiently definite to permit going from one engine to another and obtaining first-class results with the first effort. Very frequently the experience is met that a device which seems very promising on one engine will be a complete failure on another which seems to be very similar.

COMBUSTION

When the mixture finally reaches the cylinder, the heavy fuels do not burn in the same manner as the lighter hydrocarbons. When auxiliary equipment giving proper carburetion and distribution is fitted to a normal design of motor-car engine, exceedingly severe knocking occurs when fuels of the type of kerosene are used at anything like full load, that is, at normal compressions. Investigation has shown that this knocking is due to the momentary existence of exceedingly high pressure in the engine. At the 1919 Annual Meeting of the Society, C. F. Kettering gave a report covering some experimental work with a special type of indicator which has demonstrated conclusively not only the existence of these



THE STARTING BURNER APPLIED TO A SIX-CYLINDER AUTOMOBILE ENGINE ENABLED THE CAR TO BE RUN AN ENTIRE WINTER WITHOUT A CHOKER

pressures but that they come at a point in the revolution of the engine later than the ignition and are not in any way due to what is known as preignition. This discussion by Mr. Kettering was along the same lines as an informal report before the S. A. E. Council at a meeting in Dayton nearly a year ago.

At present the only commercial way of eliminating this knock is to reduce the compression which, of course, has an injurious effect upon the power and economy. Introducing a certain amount of water with the fuel will permit the compression to be somewhat higher than without water but less than with gasoline. Apparently the effect of the water is to hold down the maximum temperatures reached during combustion due to the heat required for its evaporation.

In the January, 1919, number of *The Automobile Engineer* of London, Harry R. Ricardo discusses the probable nature of the fuel knock and some methods of handling it in engines of compressions such as are used today for vehicle work. Mr. Ricardo's scheme is, briefly, to mix with the secondary air of the carbureter a certain amount of cooled exhaust gases, a method which has found previous application in engines operated with producer gas. This idea is very suggestive and deserves to be very carefully investigated. Some investigators have told me that they tried this method without success several years ago. Mr. Ricardo's test report covers the work on a single-cylinder engine on speeds up to only 1400 r. p. m. Where an attempt is made to distribute to a multiple-cylinder engine, temperatures in the mixture must be used which tend to make the knock more severe and require a greater reduction of compression than is necessary in a single-cylinder engine. The Ensign fuel converter, which burns a part of the fuel to vaporize the remainder and which permits the products of this partial combustion to enter the cylinders with the remainder of the fuel, evidently will permit higher compressions than would be possible with a vaporized kerosene mixture at the same temperature. This fact seems significant in connection with the results reported by Mr. Ricardo. I have not had sufficient experience with this latter device to justify a surmise as to the reasons for the results obtained.

The most important problem to be solved in handling the heavy fuels in the motor-car engine is to find a means of eliminating the fuel knock. The decrease of compression is very undesirable from the standpoint of efficiency and power. Anything that can be done to the engine or to the fuel which will permit the use of the usual gasoline compression will go far toward solving the ultimate problem. A vehicle engine for motor-car work must, of course, be very flexible and do the most of its running at comparatively light loads. While we cannot consider that the point is as yet definitely settled it seems pretty certain that it is desirable if not necessary to increase the temperature of the combustion chamber for light load work above that obtainable with water as a cooling fluid, certainly above that which can be obtained with a cooling mixture of water and alcohol so much used in the winter. Experience covering some thousands of engines in service all over the United States has shown that it is possible to handle a wet mixture in an air-cooled single-cylinder engine running under steady load conditions without pollution of the crankcase oil or the formation of injurious carbon deposits and when obtaining very satisfactory economy. This indicated that a high temperature in the combustion chamber will take care of the effects of previous lack of vaporization. The hot combustion chamber walls undoubtedly tend to prevent the condensation and depositing of fuel.

A theoretical reason for using higher temperatures with the heavy fuels is supplied by the fact that a saturated petroleum vapor tends to condense when compressed unless additional heat is supplied. If the temperature of the uncompressed mixture is above that of the cylinder walls the mixture cannot draw any heat from the walls during compression and may remove heat from the compressed air adjacent to it to the point where the fuel mixed with these layers will condense. In the *Report of the French Academy of Science* for March 4, 1918, there is a short paper by M. Jean Rey giving data for the entropy curve of petroleum. If it proves absolutely necessary to raise the temperature of the combustion chamber, naturally a very complete redesign of the engine will be necessary.

A trouble which is usually met in engines running on kerosene is the dilution of the crankcase oil with the heavier portions of the fuel. A great portion of this trouble is undoubtedly due to the faulty distribution and vaporization of the fuel by the devices with which the engines have been equipped in the past. As previously mentioned, it is pretty well established that this trouble is practically negligible in engines which are run under constant speed and at approximately full load where the temperature conditions in the combustion chamber are such that complete vaporization is obtained. It is, therefore, probable that more complete investigation will show that this trouble can be eliminated by proper design of the distribution system and the engine itself. If not, means must be found to remove the condensed hydrocarbons from the lubricating oil, or to prevent them from reaching the oil.

Mr. Ricardo has developed for the British Tank Service a special type of engine having a guide for the upper end of the connecting-rod, independent of that part of the piston which carries the ring. This construction has the incidental benefit of preventing any leakage past the rings from reaching the crankcase and would undoubtedly be a very complete method of preventing the pollution of the lubricant. However, the construction requires numerous engine changes and it is very likely that less expensive means will be found to obtain the required result.

To date very much more effort has been expended in attempting to mix the fuel with the air in the proper proportions and distribute it among the cylinders of the engine than has been made to handle it properly in the cylinders after it once reaches them. This has undoubtedly been due to the fact that commercial conditions have led the engine manufacturer to concentrate on production and on detailed improvements in his standard product, leaving the development work along the line of handling heavier fuels to accessory manufacturers or to investigators working with very limited facilities for experiments.

The problem has not been properly understood by a great many workers in this field, with the result that the necessity of meeting new conditions in the cylinder has not received the proper attention. The present fuel situation makes the problem very pressing. If manufacturers are to continue their present schedules they must have engines to handle heavier fuels in the immediate future. The only possible contingency that could prevent this need would be the development of commercial cracking processes to the point where an ample supply of fuels that are satisfactory when burned in present-type engines will be available. Failing this, the industry will soon be

compelled to slow down owing to lack of sufficient fuel of the quality required at present.

When we examine the data that are available today, we must admit that there is no demonstrated means by which the heavy-fuel carbureter engine will improve the fuel situation to any great extent. The equipments which have shown promising results in service have handled nothing heavier than kerosene. At present only about half as much kerosene as so-called gasoline is being produced. If the outfits now available were marketed in quantity and applied to truck and tractor engines and to the moderate-speed car engines where their use would not sacrifice performance unduly, only about 50 per cent more fuel would be available. Fifty per cent increases, while highly desirable, do not begin to meet the situation before us.

Nearly half the petroleum is marketed as gas and fuel oil, a quantity over twice that marketed as gasoline, averaging all crudes. The heavy-fuel carbureter type engine can probably handle some of the lighter fractions of gas and fuel oils, particularly in the case of petroleum from some fields. The probable result of putting heavy-fuel engines on the market in quantities would be, first, a rise in the price of kerosene and next a fall in volatility and an increase in density such as we have been having with gasoline. In 2 years the engine pronounced satisfactory today would sound like a 1910 model on a cold morning. To prevent this condition from developing, it will be necessary to make the heavier fuel engine capable of handling all of the fractions, beginning with the gasolines and down through the fuel oils. We are not yet ready to do this with the carbureter type of engine. We must remember also that the motor-car industry may not use all of this fuel oil. A large part of it will be required for marine and power engines of the Diesel and semi-Diesel type. For the motor-car industry to take proper steps to meet the fuel situation a fuel priority board would be needed to tell us what part of the total supply of the petroleum we could use. With this information the development work could be pushed. As it is some work may be wasted as the fuel on which it is based may not be available in the very near future.

The Discussion

H. Schreck:—Mr. Hunt has presented a very interesting paper on his experience with the difficulties of evaporating and burning kerosene in automobile engines. Although my own experience in this particular line is limited, it is interesting to me to hear the speaker mention a peculiar knock in the engine when burning kerosene. Nobody has so far found a satisfactory explanation for this condition. The same knock in the heavy-oil, hot-bulb engine, which generally runs at a much lower speed, will have hardly any bearing on this matter. Research work on the two types of engine should be carried on side by side. The results on one engine may enable us to draw conclusions for the other, and vice versa.

F. Gruetzner:—The difficulties encountered by Mr. Hunt in running an automobile engine on kerosene are due to the desire to gasify the oil outside of the cylinder as in the case of gasoline. They could be overcome easily if this were given up and one of the systems which have been tried out on larger oil engines used.

The Diesel principle, though theoretically and mechanically possible, cannot be used on account of the complication caused by the compressor and the use of compressed air.

The solid-injection system developed in recent years is so simple in design and operation that its adoption for high-speed use offers no serious difficulties. It requires a compression of at least 350 lb. per sq. in. and injection of the fuel oil near the dead center of the compression stroke. The ignition pressure rises to between 400 and 500 lb. per sq. in. Careful straining of the fuel oil is essential. A strongly designed fuel pump is needed to take care of the high pressures and speeds; also a carefully manufactured spray-valve. The ignition is caused by the heat of compression. No spark-plugs are necessary and any crude oil can be burned which is light enough to run through the pipes. The system itself is developed. The time is ripe to adopt it for the automobile engine and with it the safety and economy of the large oil engine.

AIR MAIL SERVICE ADOPTS NEW FUEL

A NEW alcoholic fuel, consisting of alcohol, benzol and ether, is about to take the place of the high-grade airplane gasoline, which has previously been used in the Air Mail service. The new fuel has been tested out under adverse weather conditions on the New York to Washington route, and it is contemplated that the new carbureters required for the proper use of this fuel will shortly be attached to all airplanes operating on mail service routes.

The advantage of this fuel lies in the resulting cleanliness of the engine, reduction in the cost of upkeep and its burning cooler than gasoline, which to some extent overcomes the objection to a high-compression engine when operating at low altitudes. It requires about four-fifths as much of the new fuel for any given distance and altitude. This gives greater flying radius to the planes and will enable the De Haviland Fours to cover the New York to Cleveland route, a distance of 430 miles, in a non-stop flight. It reduces the probability of forced landings by keeping the spark-plugs and the engine cylinders clear of carbon deposits and accumulations of oil.

AERONAUTIC ENGINEERING COURSES FOR THE ARMY

THE Military Affairs Committee is considering a bill authorizing the Secretary of War to detail not over twenty-five officers of the Army to attend courses in aeronautic engineering or associate studies at selected schools, colleges and universities. The tuition of such officers, the expense of textbooks, technical supplies, etc., are to be paid by the Army Air Service, and the institutions to which such officers are detailed are to receive equipment and material from the War Department for use in connection with their courses in aeronautic engineering. This equipment is to be subject to rules for use, compensation for use, report and return to the War Department.

STATISTICS OF OIL PRODUCTION

INCREASED production of gasoline and all kinds of oil in the 6 months ended June 30, 1919, as compared with the previous year, is indicated by the statistics compiled by the Bureau of Mines. These give a comparative analysis of production and consumption for the first half of 1918 and 1919 together with tabulated statements of the output of the refineries for the month of June and the stocks on hand on July 1. The last two tables are divided into districts as well as products so that the output of oil for a certain section of the country can be readily ascertained.

The stocks on hand on June 30, 1919, show increases in every product, as compared with the corresponding date of 1918, except kerosene. Here the quantity on hand on June 30 declined from 426,285,676 gal. in 1918 to 252,542,434 gal. in 1919. As the production for the first 6 months of the current year was 1,045,746,955 gal., as compared with 857,939,205 gal. in 1918, this decrease is due almost entirely to the marked jump in the exports of this oil to foreign countries which increased from 251,965,121 gal. in the first half of 1918 to 475,290,524 gal. for this year. The gasoline production in June, 1919, amounted to 338,336,985 gal., or at an average daily rate of 11,277,899 as compared with 10,500,781 and 7,789,058 gal. in 1918 and 1917 respectively. The exports in the two 6-months' periods were 177,798,652 gal. for 1919 and 275,373,335 gal. for 1918. In spite of an increased domestic consumption from 1,385,885,934 gal. in 1918 to 1,427,057,162 gal. in 1919, the stocks on hand were 593,896,610 gal. on June 30, 1919, and 418,440,353 gal. on June 30, 1918.

COMPARATIVE ANALYSIS OF PRODUCTION AND CONSUMPTION

Income	Gasoline		Kerosene		Gas and Fuel Oils		Lubricating Oils	
	1919	1918	1919	1918	1919	1918	1919	1918
Stocks, Jan. 1, gal	297,326,983	412,256,833	380,117,829	497,750,082	659,001,357	577,899,112	138,853,574	136,855,348
Production, Jan. 1 to June 30, gal	1,911,152,705	1,674,395,440	1,045,746,955	857,939,205	3,591,438,916	3,484,701,032	409,904,213	409,265,625
Total gal	2,208,479,688	2,086,652,273	1,425,864,784	1,355,689,287	4,250,440,273	4,062,600,144	548,757,787	546,120,973
Outgo								
[1]Exports, gal	177,798,652	275,373,335	475,290,524	251,965,121	[2]507,347,261	720,294,148	147,695,436	127,404,845
[2]Shipments to our insular possessions, gal	9,727,264	6,952,651	10,122,293	6,887,925	58,323,457	2,012,510	1,364,544	1,350,684
Domestic consumption, gal.	1,427,057,162	1,385,885,934	687,909,533	670,550,565	2,872,978,918	2,789,588,727	224,313,032	259,049,187
Stocks June 30, gal	593,896,610	418,440,353	252,542,434	426,285,676	811,790,637	550,704,759	175,384,775	158,316,257
Total gal	2,208,479,688	2,086,652,273	1,425,864,784	1,355,689,287	4,250,440,273	4,062,600,144	548,757,787	546,120,973

[1]Figures are taken from reports of the Bureau of Foreign and Domestic Commerce.
[2]Includes fuel or bunker oil for vessels engaged in foreign trade. 1919—5,053,957 bbl. 1918—2,975,106 bbl.

OUTPUT OF REFINERIES IN THE UNITED STATES FOR JUNE, 1919

1919	East Coast (New York, Philadelphia and Baltimore)	Pennsylvania, New York, Eastern Ohio and West Virginia	Western Ohio, Indiana, Illinois, Kentucky and Tennessee	Oklahoma and Kansas	Texas and Louisiana	Colorado and Wyoming	California	Total	Daily Average for June		
									1919	1918	1917
Crude run, bbl	6,389,623	1,735,649	2,080,071	5,046,590	7,034,825	1,153,957	5,480,049	28,920,764	964,025	938,016	881,774
Oils purchased and rerun, bbl	619,519	121,028	507,005	680,944	739,785	491,863	831,865	3,992,009	133,067	116,109	......
Gasoline, gal	63,103,531	21,669,372	59,634,838	75,429,248	66,130,421	17,767,128	34,602,447	338,336,985	11,277,899	10,500,781	7,789,058
Kerosene, gal	61,560,627	15,575,094	8,314,045	28,982,747	44,851,573	4,671,841	15,018,297	178,974,224	5,965,807	5,061,342	5,049,244
Gas and fuel oils, gal	109,886,293	12,413,819	39,533,139	110,611,686	160,047,039	24,713,320	175,000,509	632,205,805	21,073,527	20,961,401	16,558,081
Lubricating oils, gal	20,490,501	14,739,920	4,064,092	9,343,638	10,085,495	156,206	5,756,301	64,636,153	2,154,538	2,480,700	2,034,858
Wax, lb	17,362,055	6,587,431	2,111,456	2,584,255	5,967,991	78,567	126,349	34,818,104	1,160,603	1,377,260	1,275,656
Coke, tons	16,635	1,710	7,358	3,834	9,927	1,898	......	41,362	1,379	1,553	1,417
Asphalt, tons	35,687	33	402	22	21,276	......	15,745	73,165	2,439	1,677	2,264
Miscellaneous products, gal	8,075,638	7,512,922	26,039,822	10,333,669	26,371,605	18,396,048	24,770,314	121,500,018	4,050,000	2,703,697	1,006,839
Losses, bbl	406,445	109,946	142,257	170,746	260,974	68,311	157,069	1,315,748	43,858	42,739	33,719

Stocks on Hand at Refineries June 30, 1919

1919	East Coast (New York, Philadelphia and Baltimore)	Pennsylvania, New York, Eastern Ohio and West Virginia	Western Ohio, Indiana, Illinois, Kentucky and Tennessee	Oklahoma and Kansas	Texas and Louisiana	Colorado and Wyoming	California	Total Stocks June 30	
								1919	1918
Crude oil, bbl	2,281,782	1,453,525	1,005,918	2,705,682	6,960,241	801,390	1,567,185	16,775,723	11,956,151
Oils purchased to be rerun, bbl	206,839	110,511	282,850	63,956	159,017	64,631	382,666	1,270,470	932,561
Gasoline, gal	173,012,530	23,667,516	114,418,046	87,836,895	131,378,802	32,418,400	31,164,421	593,896,610	418,440,353
Kerosene, gal	72,539,508	21,864,669	18,580,235	11,309,943	112,868,020	2,737,078	12,642,981	252,542,434	426,285,676
Gas and fuel oils, gal	104,863,015	25,266,569	43,952,235	190,860,894	222,567,336	23,313,414	200,967,174	811,790,637	550,704,759
Lubricating oils, gal	72,272,659	29,272,028	19,197,180	14,682,711	26,169,605	211,418	13,579,174	175,384,775	158,316,257
Wax, lb	101,277,571	38,055,854	37,129,785	7,760,293	69,305,337	506,308	670,266	254,705,414	169,424,428
Coke, tons	9,824	2,408	7,067	12,448	6,812	4,848	....	43,407	17,478
Asphalt, tons	45,458	2,841	9,783	16	37,475	11	12,800	108,384	97,631
Miscellaneous products, gal	89,887,426	31,087,080	52,202,177	41,747,856	159,969,672	12,502,850	65,078,[illegible]43	452,475,704	273,877,024

INSPECTION OF GERMAN MOTOR TRUCKS

Arrangements have been concluded with General Charles B. Drake, chief of the Motor Transport Corps, whereby the members of the Society will be enabled to send representatives to inspect the German motor trucks which have been stationed at Camp Holabird, near Baltimore, Md., but have recently been moved to Washington. A general survey of the trucks is being made by the Motor Transport Corps, with the assistance of the automotive associations. With a view to making the inspections valuable as well as of benefit to manufacturers through obtaining the data they seek, it has been arranged that companies may send their engineers or other representatives to inspect the trucks or parts thereof, first advising what features of construction are of particular interest to them. Upon application at the office of the Society, members will be furnished with credentials for presentation at Washington for authorization to inspect the trucks. Those receiving credentials from the Society should report at the office of the Motor Transport Corps, Seventh and B streets, Washington, to General Drake, Col. W. F. Herringshaw or Capt. G. R. Young, and take up the general plan of the proposed investigation with these officers. After this conference a pass to inspect the trucks will be issued.

Two methods of investigation may be followed: A brief general examination followed by recommendations to the Motor Transport Corps officers and engineers, leaving the full detailed study to them, the Motor Transport Corps being guided by the expert advice received; or the Society members or their representatives may remain at Washington and conduct the detailed investigation in cooperation with the Motor Transport Corps.

The Government had the trucks brought to this country for the purpose of aiding not only the War Department but the motor-truck industry as a whole. It is understood that all information obtained will be available to the entire industry. The duration of the investigation is limited to Oct. 15. Prompt action on the part of any interested members is therefore essential. The trucks are not to be disassembled until after the general survey has been completed. For this reason no parts can be loaned to manufacturers until after the conclusion of the general investigation.

NATIONAL SCREW THREAD STANDARDS

For the purpose of securing as comprehensive data as possible on matters pertinent to the recommendations contained in the tentative report of the National Screw Thread Commission, which has been distributed recently for criticism by various experts, a conference will be convened at the rooms of the Society on the 8th of this month. Among those who are expected to be present are Dr. Louis A. Fischer, of the Gage Department of the Bureau of Standards; E. H. Ehrman and H. T. Herr, nominees of the Society on the Commission; H. L. Horning and Earle Buckingham, who served as alternates of the Society nominees on the Commission during its visit to England and France this summer; Col. E. C. Peck, who has been representing the Army on the commission; R. P. Smith, Packard Motor Car Co.; L. P. Kalb, Standard Parts Co.; W. K. Jamison, Domestic Engineering Co.; Paul W. Abbott, Lincoln Motor Co.; Lyle K. Snell, Willys-Overland Co.; B. H. Blood, Pratt & Whitney Co., and President Charles M. Manly of the Society.

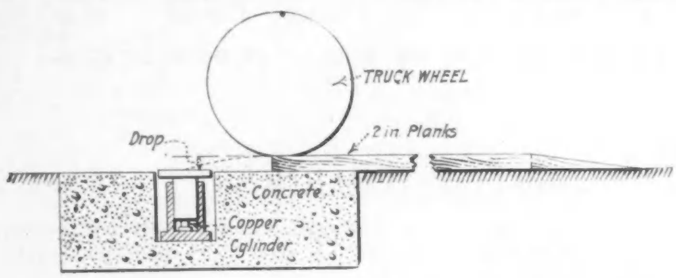
THE FARMER THE BIGGEST USER OF MOTOR TRUCKS

The American farmer is the largest user of motor trucks in the world. In 1917, the last year for which complete statistics are available, there were 79,789 motor trucks in operation by farmers. Manufacturers ranked next with 75,928 trucks, while 74,486 vehicles operated by retail merchants took the third place. While the estimates for 1918 show a marked increase in the number of motor trucks in use, the farmer still retains his leading place. It is estimated that in the last year approximately 350,000,000 tons of farm products was hauled to market in motor trucks by the farmers and market gardeners of this country. The cost of handling this large quantity of produce, much of which was of a perishable nature, was approximately half that of horse-drawn transportation, according to an average of the actual operating figures which have been compiled for the entire United States and cover a wide range of local conditions.

Impact Tests of Motor Trucks on Roads[1]

REALIZING the effect of heavily loaded motor trucks on highways and streets, and feeling the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads (U. S. Department of Agriculture) at the Arlington Experimental Farm near Washington to determine the impact of motor trucks on roads.

The apparatus used in these experiments consists of a heavy steel cylinder in which is fitted a plunger 4 in. in diameter and 8 in. long, similar in construction to a hydraulic jack. A hole is left in the bottom of the cylinder to prevent air cushioning under the plunger. On the top



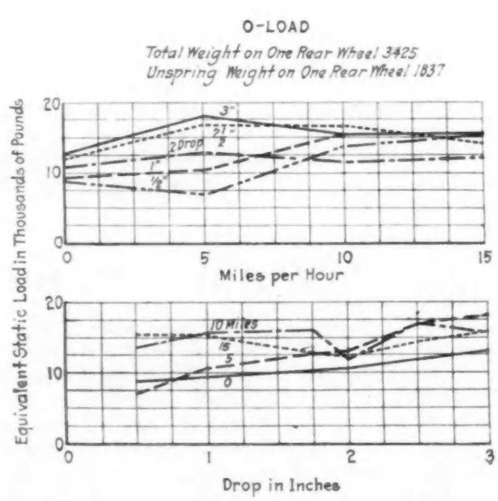
ARRANGEMENT OF APPARATUS USED IN THE IMPACT TESTS

or head of the plunger is securely fastened a heavy steel plate on which is received the impact of the truck wheel. This whole apparatus is rigidly supported in a concrete box placed in the road in such a position that the height of the steel plate on top of the plunger can be made just flush with the road surface. The height of the upper surface of the plate can be varied by proper steel disks placed under the plunger. To allow the front wheel to pass over and not touch the steel plate on the plunger, a steel bridge is used which is automatically tripped by the front wheel passing over it. This releases a catch and allows a weighted lever to pull the bridge clear from the apparatus, thus leaving the steel plate exposed and ready to receive the impact of the rear wheel. By slight variations this bridge can be used to allow the impact of the front wheel to be received and then protect the plate from the impact of the rear wheel. The approach to this impact apparatus is made of 2-in. planking about 20 ft. long and is constructed so that the height of the planks can be varied above the road surface to give different heights of drop and also be moved forward or backward to give the proper distance from the jump-off point so that the wheel will strike the center of the plunger at all speeds.

For recording the impact value, a copper cylinder of ½ in. diameter and ½ in. long is placed under the plunger of the jack. The impact received on the plunger is transmitted to the copper cylinder where it produces a corresponding permanent deformation. The cylinders for this investigation were prepared from pure copper bars and carefully machined to dimensions. They were then annealed by heating for 30 min. at a uniform temperature of 650 deg. cent. in a bath consisting of a mixture of 20 per cent of potassium nitrate and 80 per cent sodium nitrate, followed by slow cooling in the air at room temperature. This treatment anneals the copper very uniformly. The finished cylinders were tested for uniformity in a universal testing machine under a pressure of 6000 lb. total static load, five cylinders being taken from each heat-treated lot. Thus far the maximum variation from the mean deformation value has been only 1.3 per cent and this is less than other experimental errors.

A 3-ton Class B truck, with solid rubber tires, was used for the experiments. The weight of the truck empty is 11,400 lb.; the weight on front wheels, 4550 lb.; the weight on rear wheels, 6850 lb., and the weight of unsprung rear parts, 3675 lb. The deflection of the rear spring under the weight of the body alone is 0.74 in. The weight on the rear wheels when loaded with 7200 lb. of gravel is 13,100 lb., and the deflection of the rear spring, due to the load and the body is 2.62 in. The weight on the rear wheels when loaded with 10,000 lb. of gravel is 15,500 lb. and the deflection of the rear spring, due to the load and the body, is 3.62 in. The diameter of the rear wheels is 40 in. and each is fitted with two solid rubber tires, each of which is 6 in. wide at the base next to the rim. Impact values were obtained only for the rear wheel, as it was the object of the test to obtain values of the maximum impact of the truck. The rear springs were 57½ in. long, 4 in. wide and 6½ in. deep, with 17 leaves.

The impact condition under which these tests were conducted was the simple falling of the truck wheel from one level to another at different speeds of the truck, the height of drop varying from ¼ to 3 in. Other conditions of impact will be investigated later. The magnitude of the impact is dependent upon the height of the drop, the weight of the truck and the load, the kind and condition of the tires, the characteristics of the springs and the speed of the truck. Under these conditions, a series of tests was run, and the results are shown on the accompanying curves. The impact, while measured by the shortening or compression of the copper cylinders, is shown in equivalent static load. That is, for each compression value of the copper due, the static load which would produce the same compression has been determined. All the curves are thus shown with the equivalent static load as ordinates. This may not be a perfect comparison of impact loads, as loads applied with impact will probably produce a much localized shattering effect which does not result from the application of an equivalent static load. For this reason, the present methods of



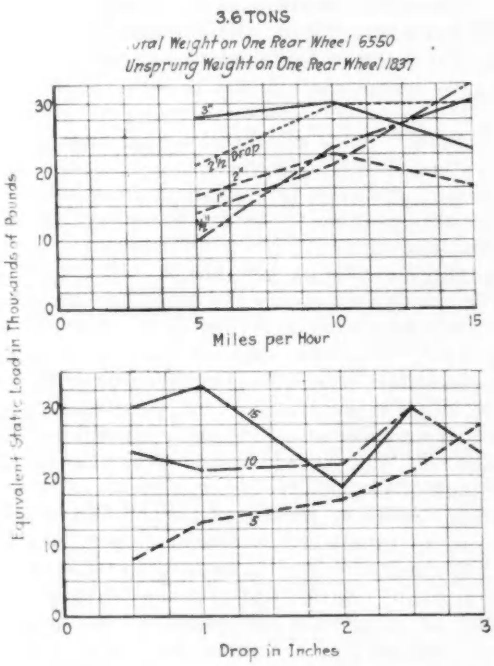
RESULTS OF IMPACT TEST OF AN UNLOADED 3-TON TRUCK

[1]From a preliminary report by E. B. Smith and J. T. Pauls. The authors are connected with the Bureau of Public Roads of the Department of Agriculture as senior testing engineer and highway engineer respectively.

comparing impacts by the equivalent static loads must be considered as tentative and subject to possible revision as the tests proceed.

The tests thus far give only the relative impact values, and do not attempt to demonstrate the destructive effect of these impacts. This destructive effect depends upon the road surface, the type of construction and the foundation. To arrive at the destructive effect of these impact forces, it is proposed in another series of experiments to subject certain road surfaces to these same impacts repeatedly until failure occurs. Machinery and apparatus for this purpose are now under construction.

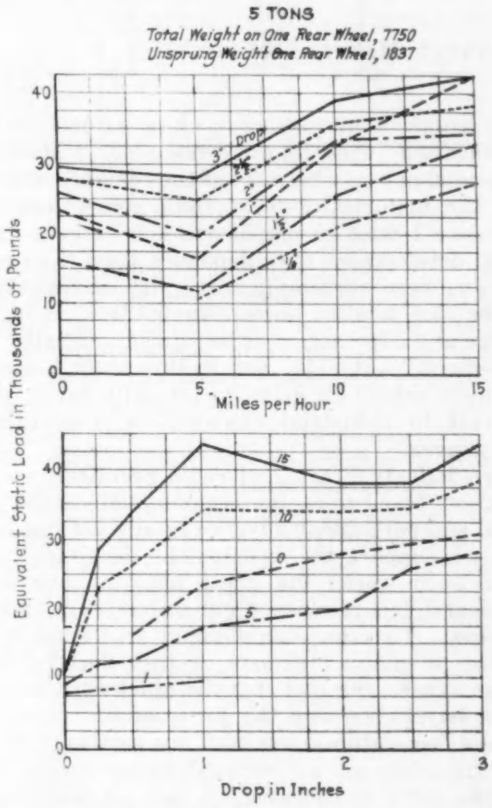
The results shown indicate a general tendency of increased impacts toward the higher speeds, although the increment of increase is less as the speed increases. The relatively high impact values at zero speed are explained by the fact that the results were obtained by dropping the wheel vertically upon the impact plunger. This resulted in the copper cylinder receiving first the impact or kick of the spring and then an additional load an instant later from the falling of the truck body and load.



Results of Impact Test of a 3-Ton Truck When Carrying a Load of 7200 Lb.

The same data were plotted with the height or drop as abscissas. These curves indicate a general increase of impact with the increase of the height of drop.

In conducting these experiments it was soon discovered that the action of the truck springs had a great influence on the impact results. When the wheel leaves the jump-off point the spring, it is said, produces a greater downward acceleration of the unsprung parts than that due to the action of gravity alone. If the compression of the spring is e, and the height of the drop or jump-off point is d, then within the time of one vibration of the spring, the magnitude of the impact at the landing point will depend upon whether $d<e$, or $d = e$, or $d>e$. If the period of vibration is such that the spring has acquired its maximum acceleration and at this instant also lands at the point of impact on the road surface, the impact value will be a maximum. The impact value will be a minimum



Results of Impact Test of a 3-Ton Truck with a 5-Ton Load

when conditions are such that the spring is returning to its closed position and is at the point of maximum acceleration in this direction as the impact occurs. This explains why the impact values, as shown in the curves, do not consistently increase with the height of drop. The static loads equivalent to the impact values under the higher loads and drops are as much as five times larger than the total dead load.

It was also noticed during these tests that the impact was appreciably affected by the conditions of power on or off. That is, if the impact occurred when coasting, it was less than when the power was being applied to the rear wheels. This difference amounted in some cases to as much as 30 per cent.

These results are presented at this time only for the purpose of showing the general tendency of the impact values. It is the intention to enlarge upon this investigation to determine the relative effects of kinds of tires, loads, speeds, spring characteristics and character of road obstructions and defects which produce impact values and to attempt to arrive at some definite conclusions as to the destructive effect of truck loads on different types of road. It is hoped that this will ultimately result in definite road design data, and also lead to information as to allowable loads and speeds for motor trucks. Special apparatus is being designed to obtain autographic records of the tests.

Vol. V September, 1919 No. 3

Radio Telephony

By E. H. Colpitts[1] (*Non-Member*)

Semi-Annual Meeting Address

Illustrated with Drawings and Photographs

IT is usual in discussing such a subject as this to touch briefly upon its historical side. I shall do so in this case, not only because of the romance and fascination of the historical side of radio communication, but also because I wish to emphasize how largely its beginning and development have depended upon the researches of men who were working in university laboratories to advance the sum total of human knowledge. It is well for us to urge and advocate, as is being done, so-called "industrial research," but today and in this country much serious thought should be given to the stimulation of what, in contrast to industrial research, is frequently called "pure research."

Modern industrial art, and radio peculiarly so, is to a great extent based upon the accumulated results of pure research, and permanent advance in any art can continue only as we support the institutions peculiarly fitted to carry on such work; the great physical, chemical and other research laboratories of our universities and similar institutions. To urge such support may seem trite and threadbare to many members of this Society, but if I needed an excuse, the fact that the nineteenth amendment will soon be ratified and the presence of ladies—future voters and legislators—warrant my urging this matter to their attention, so that such laboratories may not only receive the gifts of the wealthy, but, as seems wise, be liberally supported by the state or the nation.

Early Experimental Work

Very suitably we may mention Michael Faraday, the great experimenter of the early nineteenth century, as laying the broad foundation of modern electrical art and science by his researches in electricity and magnetism. While an Englishman, America can take some pride in Faraday's work, for it was an American born in Massachusetts—Benjamin Thompson—who had founded the Royal Institution in London in which Faraday was trained and later did his work. It is told of Faraday that one day someone asked him: "What is the good of all your puttering around with magnets and pieces of wire?" His reply was: "What is the good of a baby?"

Building on Faraday's work and seeking to link his early results together by a consistent theory, James Clerk Maxwell in the sixties of the last century gave the first intimation to the world of the existence of phenomena and laws which have later been utilized as the basis of radio communication. Maxwell's promise took the form of mathematical equations from which he was led to infer the existence of electromagnetic wave propagation in space at the velocity of light and that such electromagnetic waves differed from light only in wave length.

In the seventies and eighties of the last century, following Maxwell's masterly theoretical work, there was much discussion and analysis of his theories, and some noteworthy experimental work was done by various physicists, but it remained for a brilliant young German physicist, Heinrich Hertz, to produce and transmit electromagnetic waves through space. Professor Hertz not only detected these waves in space but showed that they were propagated with the velocity of light, could be reflected and were refracted as are light waves. In a word, he experimentally confirmed Maxwell's theory. Hertz had a very insensitive detector and used small power, but the basis of the radio art was experimentally laid.

Meanwhile the principle of electrical tuning or of tuned electric circuits was becoming well understood, and an improved detector—namely, the coherer—had been devised by Professor Branly of the Catholic University of Paris. Means for securing and radiating greater power had also been suggested. The stage was now set for the man who had the confidence to do the *practical* thing—what now seems the obvious thing—certainly the dramatic. This man was Marconi, and you know his well-deserved fame. In brief, Marconi passed from the oscillating system of Hertz to the grounded antennas at both the sending and receiving stations, and applied tuned circuits to such systems to secure increased efficiency and selectivity, not to mention other less spectacular but possibly equally noteworthy advances.

Let me take you back to the quiet of Cambridge University and the Cavendish Physical Laboratory. Here we find J. J. Thomson, one of the brilliant group of modern physicists who have sought an answer to that old question "What is electricity?" and have made some progress toward an answer. Now, why should we care what electricity is? Why should we be interested in the story of discharge of electricity through gases or through perfectly empty space as presented by J. J. Thomson? Why should we be interested in electrically charged bodies 1/2000 the mass of a hydrogen atom, and known as electrons? For the reason that years after much scientific knowledge of these matters had been accumulated and published, without any so-called practical use having been made of it, the radio inventor and engineer dipped into this fund of knowledge and gradually evolved the most remarkable tools.

If our eyes had sufficient microscopic power and we looked at the incandescent carbon or tungsten filament of an incandescent lamp, we would see, surrounding the heated filament, in a state of seemingly erratic motion, billions of electrons. Some would be seen being given off or emitted by the heated filament and some would be seen reentering the filament. In scientific terms we would be observing the phenomenon of electronic emission from heated bodies. Now, instead of an eye capable of seeing these electrons we must depend on other means of detecting their presence. Fortunately the means is simple. Place inside the glass bulb a metal plate P, charge this plate positively with respect to the filament E, and it will attract these negatively charged bodies. You remember the old law "Unlikes attract." If the electric circuit is completed through the ammeter A a steady flow of electrons will pass from the filament to the positively charged plate. On the other hand, if the plate is made negative with respect to the filament, no current flows in the circuit.

In the year 1884 Thomas A. Edison became much interested in this class of phenomena. He made important

[1]Assistant chief engineer, Western Electric Co., New York City.

scientific contributions and suggested and devised the first practical application of electron apparatus, a potential control system, known as the Edison relay. This is an early example of the practical man adding to the world's stock of scientific knowledge.

We have not time to run over the practical developments of the radio art in the years following Marconi's early work, but it may be said that the foundations of the present art were being laid by the efforts of a large number of workers in the field. On both the practical and theoretical sides we have such men as Prof. R. A. Fessenden, who early experimented with radio telephony and emphasized the requirements for successful radio operation. On the more theoretical side, we shall give credit to men in the universities, represented by such names as Prof. M. I. Pupin of Columbia and G. W. Pierce of Harvard.

Electric Wave Detectors

One of the needs of the radio art was a reliable sensitive detector of electric waves. Professor Fleming in England early proposed to use as a rectifier or detector

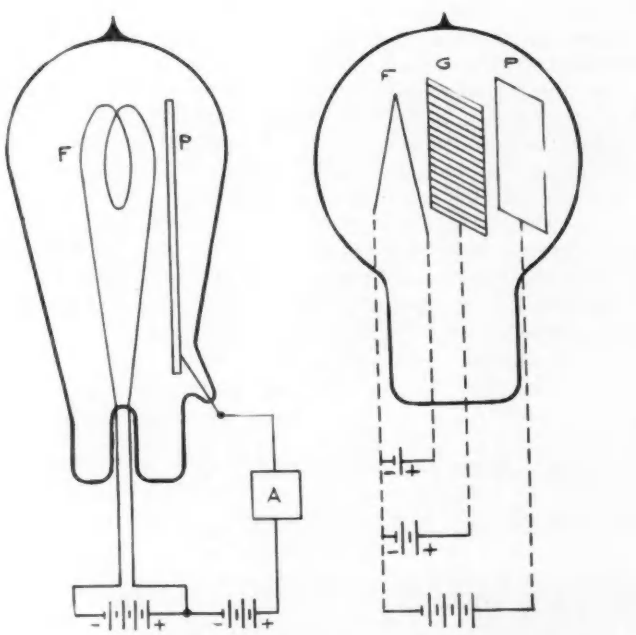


Diagram of the Principle Underlying the Method of Detecting the Emission of Electrons by a Heated Filament and Its Application in the Audion

the same device that Edison had employed, he having found that even at radio frequencies it would pass current in one direction only. Various other devices were found which also possessed this characteristic, notably contacts between certain metals and the faces of certain crystals, such as galena, etc. These several devices proved very useful and, as a fact, are still used for certain purposes.

The epoch-making application of the vacuum tube phenomena referred to above and which had been very fully described and studied by physicists in the latter half of the last century, was the invention of Dr. Lee deForest, an American worker in the radio field. This device was intended primarily for use as a detector, but it has been developed for use as an amplifier, as an oscillator or producer of high-frequency currents and as a modulator or means of varying telephonically the amplitude of these high-frequency currents. In the hands of the radio en-

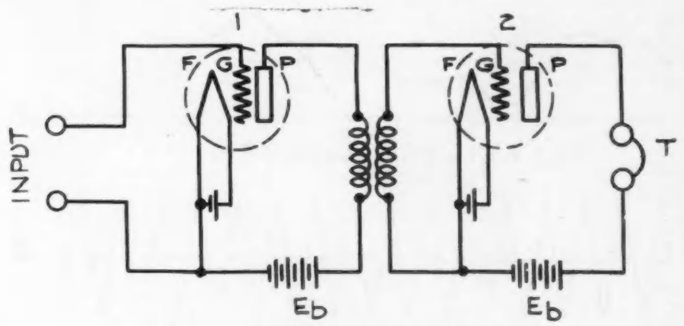
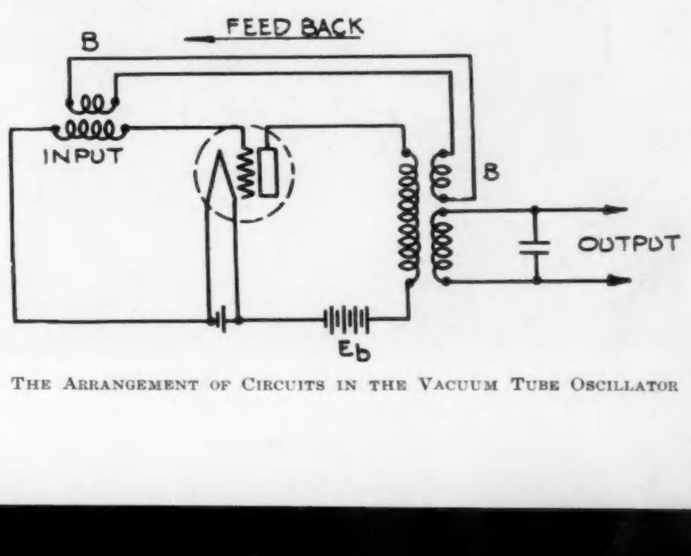


Diagram of a Two-Stage Amplifier

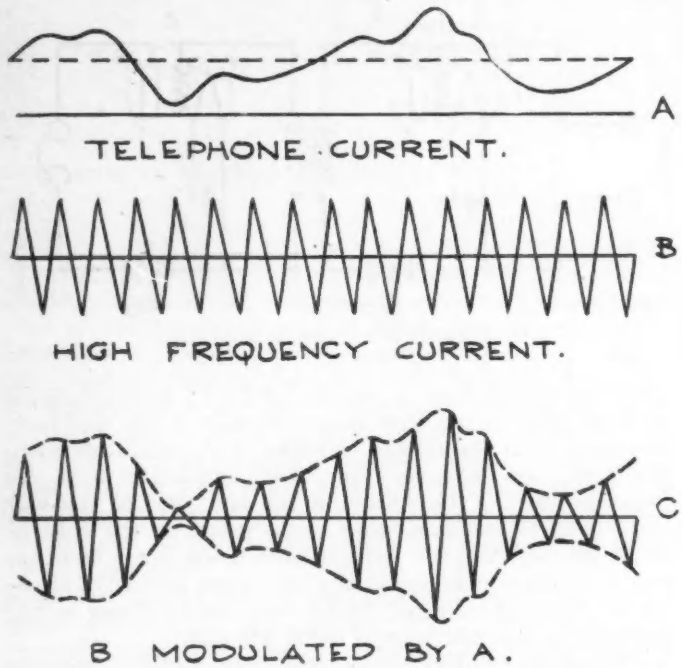
gineer it has become a wonderful tool. Incidentally, I may say that in the wire telephone field it has also been combined with the results of other fundamental developments and become a very important and useful tool. To show the use by the Allies, in the last year of the war the French were employing these tubes at the rate of about 500 per day, the British were using large numbers and their plans contemplated a still more extensive application, while the United States was having them manufactured at the rate of over 5000 per day.

This device, named by deForest "the audion," consists of a filament *F*, which may be heated to incandescence so as to make it an efficient emitter of electrons, a plate *P*, or cylinder of suitable metal, and between the filament and the plate, as you will note, a lattice grid *G*. I have already told you how the current passes from the filament to the plate. Now the grid serves a very important purpose, for by it it is possible to vary—that is, increase or decrease—the current flowing between the filament and the plate. Due to the fact that a very small amount of power in the grid circuit can control a large amount of power in the plate circuit, the device can be used as an amplifier; that is, received alternating or fluctuating currents representing a small amount of energy, when applied to the grid, can create fluctuations having the same wave form in the current flowing in the plate circuit but representing a very much greater amount of energy.

A two-stage amplifier is also shown, the same letters being used to denote the filament, grid and plate as in the audion. Very small electromotive forces applied to the grid of the first tube create proportionately larger fluctuations of the same wave form in the plate current of the first tube. The plate current of the first tube impresses relatively large electromotive forces on the grid of the second tube, which results in correspondingly larger fluctuations in the plate current of the second tube. The telephone receivers *T* are connected in series with the plate of the second tube. Hence any weak voice currents



The Arrangement of Circuits in the Vacuum Tube Oscillator



How the Current Produced by Speaking Into a Telephone Transmitter Is Modulated by the Application of a High-Frequency Current

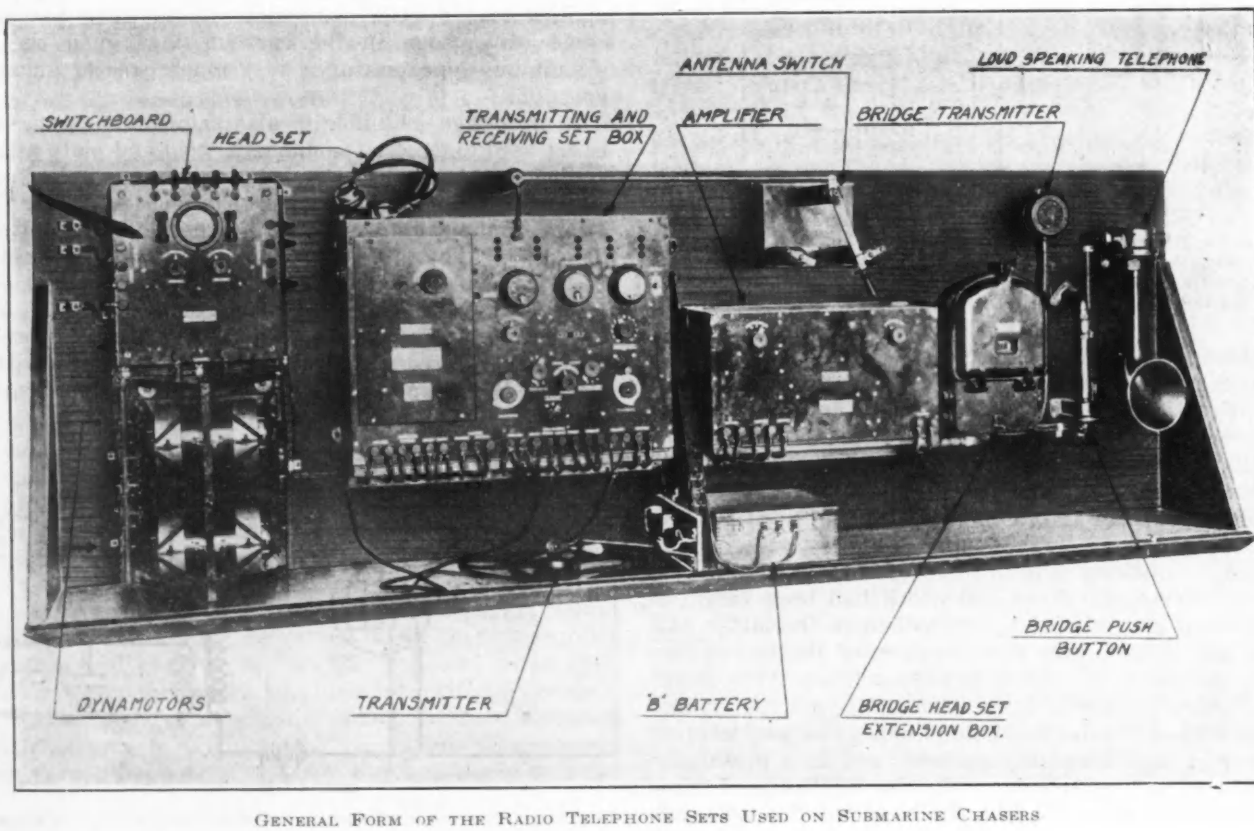
impressed on the amplifier input terminals will produce loud signals in the telephone receivers.

The device may, with suitable associated apparatus, be used to generate high-frequency oscillatory currents. It is known that any device which can be used as an amplifier of alternating currents can also be used as a generator of alternating currents over the same range of frequencies through which it will act as an amplifier. All that is necessary is to connect electrically the input and output circuits in a suitable way. One method, that of the vacuum tube oscillator, is reproduced where by using the coils *BB* a small portion of the output energy from the plate circuit is returned to the input, thus sustaining continuous oscillations. The frequency will depend upon the electrical constants of the device and of the associated apparatus. The device acts as a detector of high-frequency oscillations when operated so that the positive and negative halves of the high-frequency waves are amplified unevenly. For instance, if the positive half of the incoming wave increases the plate current very greatly and the negative part decreases it very little, then the effect is to increase the average value of the plate current during the period of application of the high frequency to the grid.

One of the serious problems connected with radio telephony over any considerable distance involves controlling telephonically the relatively large amounts of energy which it is necessary to furnish to the sending antennas. What I mean by telephonic control or telephonic modulation is the variation of the amplitude of the high-frequency antenna current in proportion to the instantaneous values of the telephone current. In an accompanying drawing the telephone or speech current is represented diagrammatically by *A*. A constant amplitude or unmodulated high-frequency current is shown at *B*. *C* represents a high-frequency current as in *B* except that the amplitude varies in proportion to *A*. Technically *C* is said to be a modulated high-frequency current controlled by the telephone current *A*.

In the early attempt at radio telephony carbon granule transmitters or other somewhat similar devices had been employed, but the current-carrying capacity of such devices was limited and they possessed other undesirable characteristics for this use.

The audion of deForest, developed in logical directions,



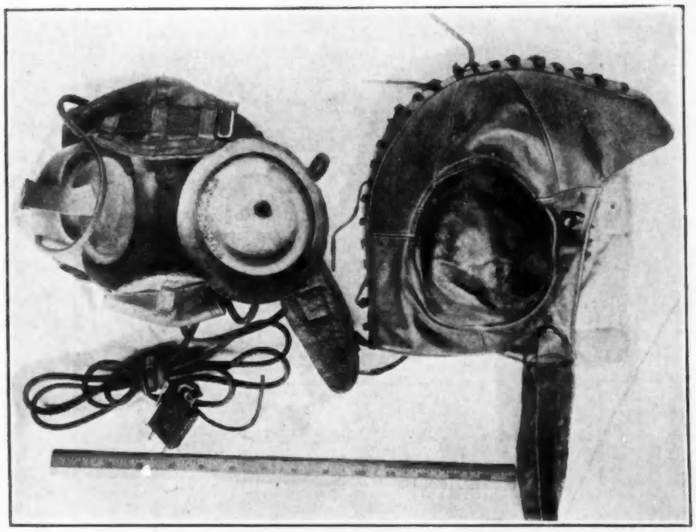
General Form of the Radio Telephone Sets Used on Submarine Chasers

can be used to very great advantage as a modulator or means for superposing telephonic amplitude variations on the continuous high-frequency current. While speaking of modulating, it should be mentioned that another method has been devised, which depends upon the magnetic characteristics of iron and is very promising, particularly for high-powered sets.

Apparatus Available at Present

Let me sum up for you what the radio telephone and telegraph engineer has today at hand. First, for receiving purposes he has this very efficient device, the audion, or vacuum tube, as a detector and as an amplifier. For transmitting, the same device can be used as an oscillator, and, in the case of telephony, it is added as a modulator. For larger-powered units the engineer also has available, as a generator of high-frequency current, the Poulsen arc, which has been highly developed in this country, the Alexanderson alternator, a most praiseworthy and promising accomplishment, and in addition alternators designed by German engineers.

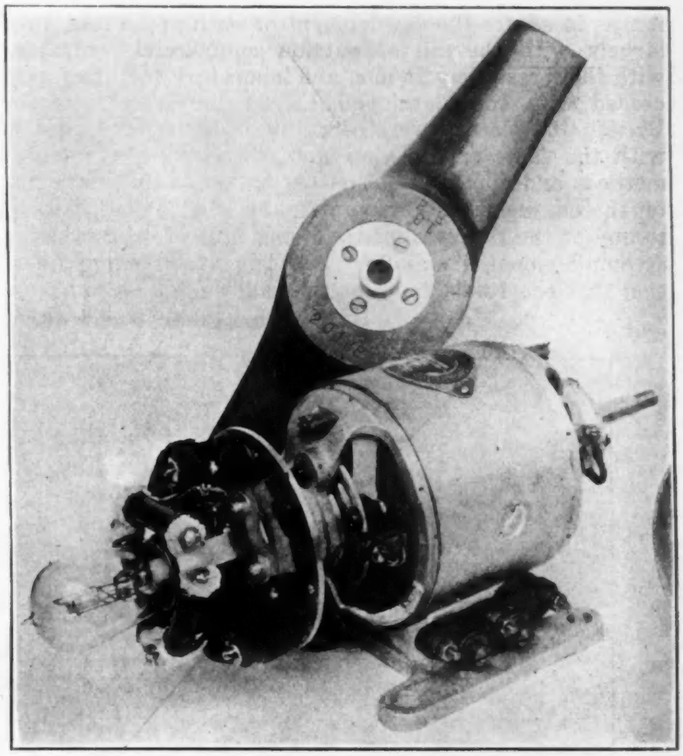
Following the more spectacular work of the telephone



The Airplane Wireless Telephone Head Set

engineers and of the United States Navy, carried on about 4 or 5 years ago, trials of radio telephony were made in conjunction with ships of the Navy to enable the Navy officials to determine its field of usefulness and to provide for a development of the art. Experimental sets were devised which furnished communication between ships and between ships and shore. In one case an officer in San Francisco talked by wire to Washington, thence by wireless to the captain on the bridge of a battleship off Cape Henry. The officer in San Francisco spoke just as if he had been talking to the same friend in Washington. The captain on the ship off Cape Henry also talked to his wife in an apartment in Washington, using her regular house telephone set, subscriber's line, etc.

At the beginning of the war, therefore, the foundations of the art of radio telephony had been laid. In the case of the Navy, important use was made of radio telephony between units of submarine chasers. Simple and what proved reasonably reliable sets were hurriedly designed and manufactured. The sets were arranged so that an officer on the bridge of one boat could talk with



The Generator Used on Airplanes and the Vacuum Tube Regulator Employed to Control the Voltage

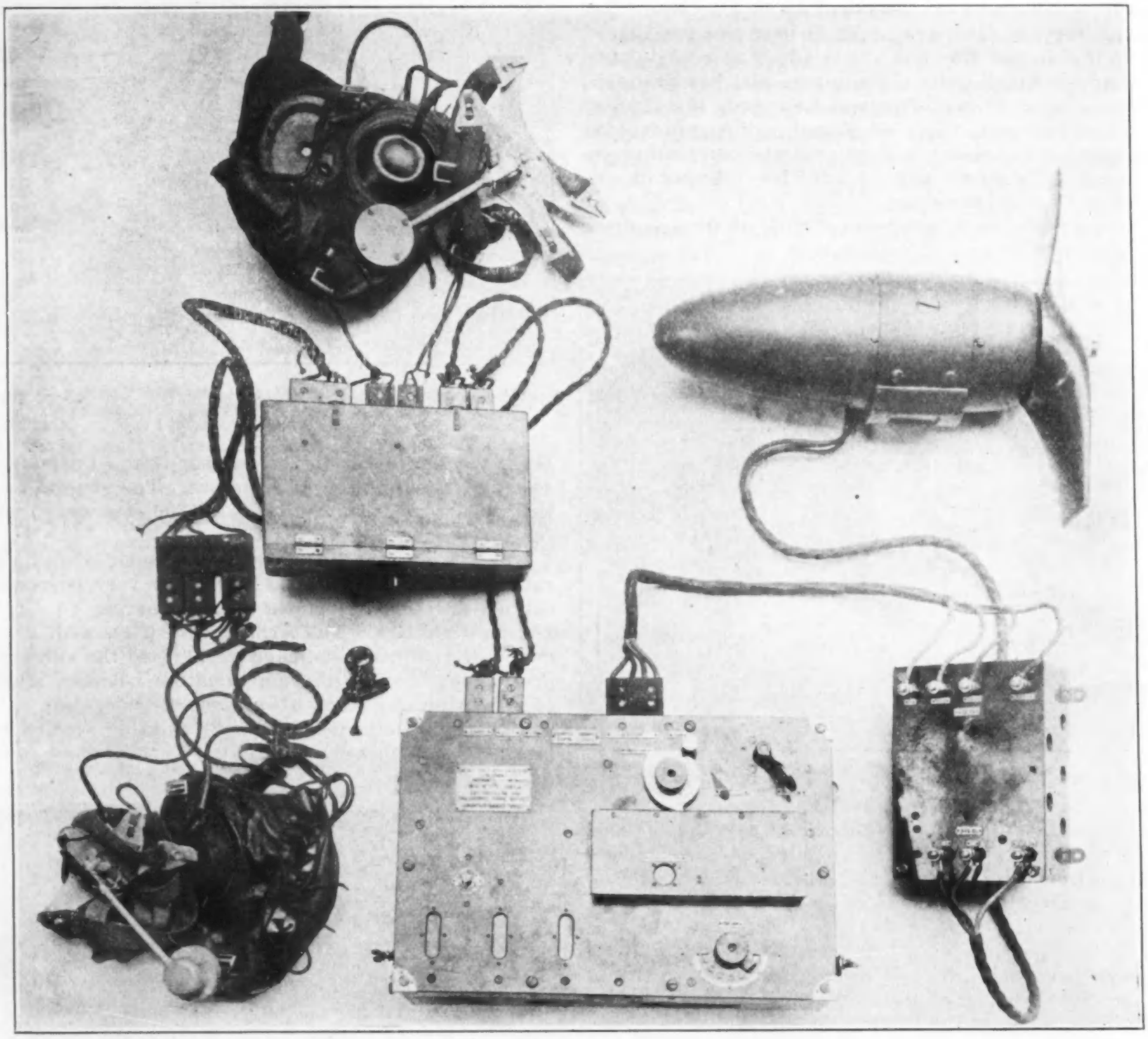
the officer on the bridge of another boat. Purposely, the range of these sets was kept down. The general form of this apparatus is shown. About 1200 sets were installed for this service.

Still more interesting is the development of radio apparatus for use on aircraft. The Navy very energetically carried on the development of sets for use on airplanes and on dirigibles. The Army authorities, with an enormous aircraft program, early recognized the value of improved means of intercommunication between airplanes of a fighting unit, and, after some consideration of various possible methods, the most desirable seemed to be interplane telephony. The Signal Corps, whose function

The Wind-Driven Generator Used on Airplanes

it was to secure the development of such apparatus, then largely with the aid of outside commercial companies with their resources in men and laboratory facilities, proceeded with this development. At the same time the British and French were carrying on their developments with the same end in view and employing very similar methods and apparatus. Neither on the tactical side nor on the engineering development side shall I imply credit to any of the three Allies for being first in conception or accomplishment in this field, but it is a fact beyond question that the fundaments of the radio methods employed were largely those which had been previously worked out by American engineers. The audion or vacuum tube was used for generating the transmitted high-frequency oscillations and this same device was used as a modulator. For receiving the audion was also used as a detector and amplifier. This is true of both Navy and Army aircraft sets.

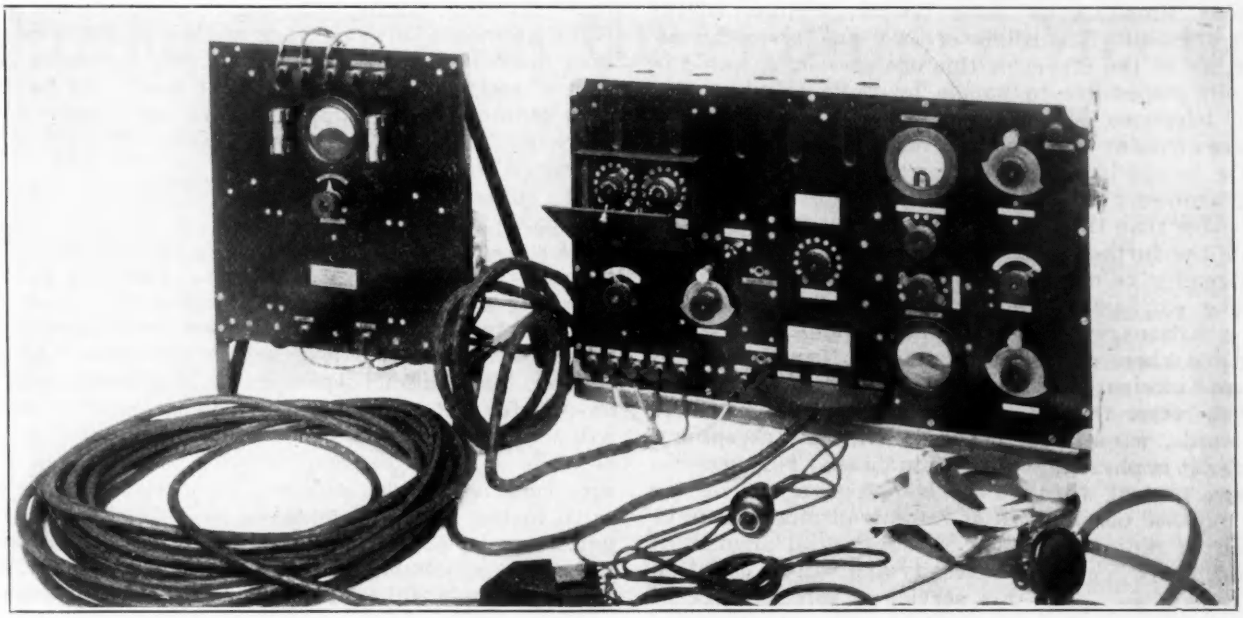
It probably occurs to you that an airplane is a noisy place from which to talk and a noisy place in which to listen. When using an ordinary telephone transmitter in a noisy place, not only the speech sound waves are picked up and sent on but also the other noises present—in this case the engine noises, etc. The problem was to design a transmitter which would be responsive to the speech sound waves and not to these extraneous sounds. Two designs were worked out, both of which have given very good results; in fact, both have given much better results than at first might have been thought possible in a practical, usable form. The problem of combining telephone receivers with an aviator's helmet has also been solved very satisfactorily.



Complete Telephone Equipment for a Two-Seater Airplane

Another problem incidental to this development was to secure means of controlling the voltage output of a fan-driven generator whose speed varied to a greater or less extent with the speed of the airplane. This was accomplished by an ingenious use of a two-member electron vacuum tube.

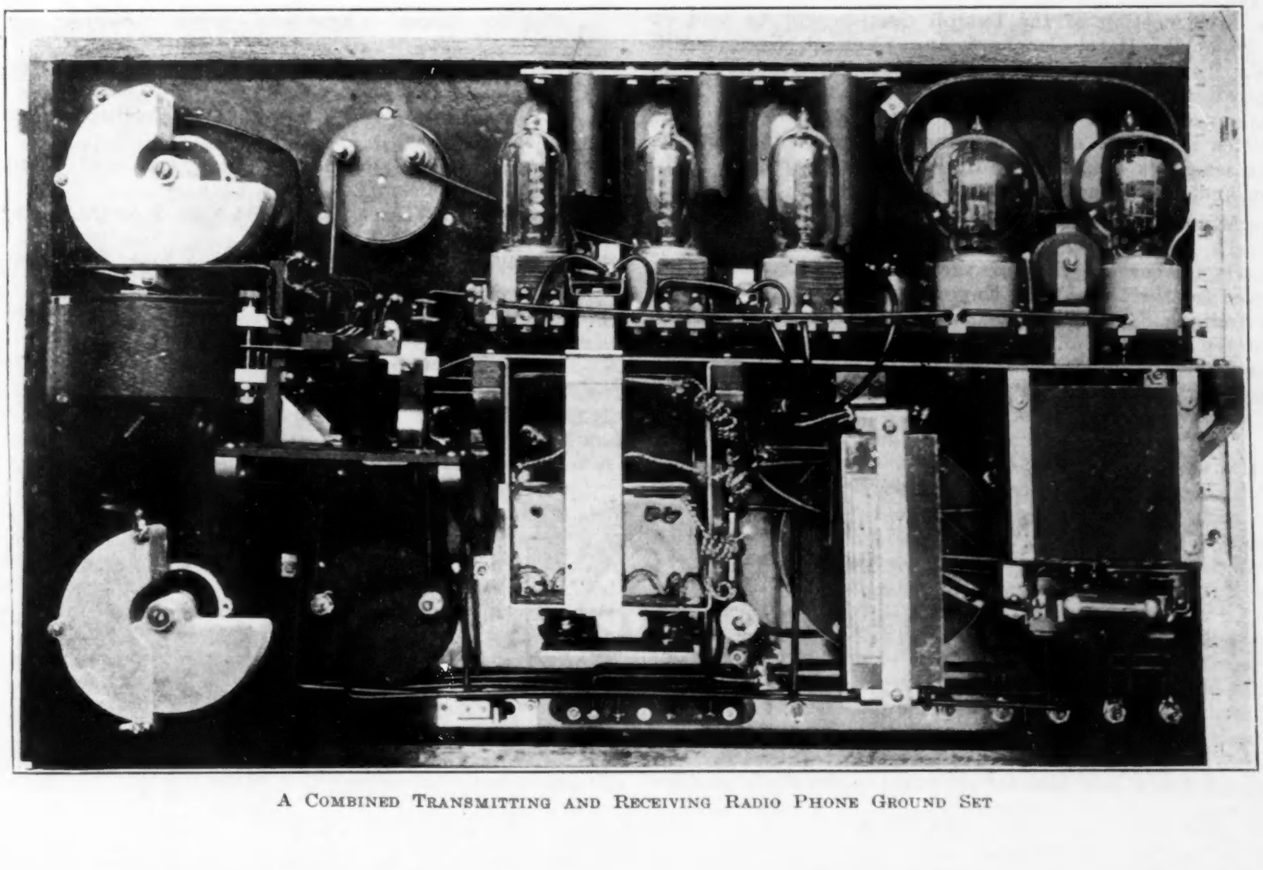
Radio telephone apparatus was also designed for emergency use between ground stations in the Army areas to be employed when the wire communications were interrupted.



A Radio Telephone Set for Use Between Ground Stations When Wire Communication Is Interrupted

The Future of Radio Telephony

As to the field for and future of radio telephony, much sense and nonsense has been talked. Enthusiasts without much or any knowledge of the important factors involved have prophesied the general supplanting by radio of the moderate length and longer telephone toll lines. Let us look for a moment at certain facts. First, in a radio telephone system, even one designed for relatively short-range working, the radiated energy at the transmitting station is enormous compared with the minute amount of energy intercepted by the receiving antennas. This means that there is a very great opportunity for interference between sending and receiving stations not intended to work together, as well as rendering the receiving station susceptible to natural electrical disturbances. Second, in radio telephony it is necessary to transmit not a single high frequency but a band of frequencies at least as wide as the range of essential frequencies found in the human voice, and as non-overhearing or freedom from mutual interference requires the use of different bands of frequencies, the possibilities of



A Combined Transmitting and Receiving Radio Phone Ground Set

numerous simultaneous radio telephone conversations become limited. Regardless of cost and assuming exclusive use of the ether for this one service, it would be physically impossible to handle by radio telephony the present telephone business between New York City and the three cities of Philadelphia, Baltimore and Washington. Or, to put it another way, more telephone business can be handled over a single 300-pair No. 19 gage telephone cable than through the ether. You, of course, appreciate the further important fact that radio telephony cannot readily be made completely secret.

Having emphasized what cannot be done, there are many situations where telephone communication is desirable and where wire service cannot be furnished. These uses are sufficiently numerous and important that the use of the ether for radio will be restricted to such. In other words, wires must be used, with few exceptions, wherever it is physically possible to do so. This becomes still more evident when we consider that only a fraction of the physical possibilities of radio transmission can be assigned to radio telephony. A substantial amount of radio telephony is a prime necessity and will no doubt always remain so. For this service a varied range of frequencies or wave lengths must be assigned. Further, radio direction finding will require a certain use of the ether, and while this system or method is now principally used in connection with shipping, with the rapid extension of aerial craft the country will eventually be dotted with radio stations equipped to send out signals for the purpose of assisting in the navigation of craft of this character through the air.

The future will therefore probably see radio telephony developed for use between ships at sea and between ships and shore stations. It will also be used, particularly in new countries, between stations separated by territory over which it is practically impossible to construct and maintain wire circuits. It is not possible to give telephone service over long submarine cables, therefore between land stations separated by long stretches of water—as, for instance, across the Atlantic—radio telephony will doubtless be used. Emergency use will also no doubt be made of radio telephony between land stations to insure continuous telephone communication. If we have faith in the future of aircraft, as I think we all have, wireless telephony will prove of very great importance and value for communication between such, and perhaps still more important for communication between airplanes and dirigibles and ground or ship stations.

ACTIVITIES OF S. A. E. SECTIONS

SOME of the Sections of the Society have already outlined their plans for the coming season and the others will do so shortly. It is expected that with the return of the numerous members who have been engaged in various Government activities the work of the Sections will be entered into with even more enthusiasm than heretofore. Many things which it was impossible to discuss before because of the absence of members and the necessity for secrecy that existed for a part, at least, of last winter can now be presented at the Section metings. A very interesting series of meetings is looked forward to.

The first meeting of the Detroit Section will be held on Sept. 26 at the Hotel Ponchartrain. Capt. O. Koester will describe the repair work which the Navy Department did on the interned German vessels by the welding process. Other meetings are scheduled for Oct. 24, Nov. 21 and Dec. 19. The committee in charge of the meetings of the Section for the coming season is composed of H. W. Alden, chairman, H. L. Barton and O. E. Hunt.

The Minneapolis Section will hold its next meeting on Oct. 1.

The September meeting of the Pennsylvania Section is scheduled for the 25th at the Engineers' Club, Philadelphia.

The Indiana Section will hold a meeting during the latter part of the present month.

Dent Parrett, chairman of the Mid-West Section, has appointed the Meetings and Papers and the Membership Committees for the coming season. The personnel of the former is Mark A. Smith, chairman; D. S. Hatch, J. G. Zimmerman and F. C. Mock. E. B. Blakely is chairman of the Membership Committee and will be assisted by George Briggs, Charles S. Whitney, Charles Cotta and B. M. Ikert.

The opening meeting of the Cleveland Section will be held on Sept. 26, at the Hotel Statler. Ferdinand Jehle, dynamical engineer of the Aluminum Castings Co., will present a paper on the Use of Aluminum in Present and Future Motor Cars.

A complete list of the secretaries of the different Sections is given below:

Buffalo—Roger Chauveau, 1100 Military Road, Buffalo, N. Y.

Cleveland—A. E. Jackman, 1900 Euclid Avenue, Cleveland, Ohio.

Detroit—Ralph H. Sherry, 701 Book Building, Detroit, Mich.

Indiana—W. S. Reed, 1602 Merchants Bank Building, Indianapolis, Ind.

Metropolitan—A. M. Wolf, 114 East Sixteenth Street, New York City.

Mid-West — C. S. Rieman, Sixty-first Street and Archer Avenue, Argo, Ill.

Minneapolis—C. T. Stevens, 13 South Ninth Street, Minneapolis, Minn.

Pennsylvania—G. W. Smith, Jr., 309 Hillside Avenue, Jenkintown, Pa.

German Trucks at the Summer Meeting

SIX trucks, Adler, Bussing, Dux, Daimler, Horch and Komnick, were selected as being interesting examples of the forty-seven in possession of the Motor Transport Corps and representative of various types in German truck practice, although not in all cases the types most used in the German army. These trucks left Camp Holabird on June 14 and after numerous delays reached their destination and were unloaded on June 22 and placed on exhibition. A more detailed description of these trucks will be published after the survey now in progress is completed. The data given herein have been furnished by the Motor Transport Corps.

Adler

This truck is of 3000-kg. capacity, approximately 3 tons, and is equipped with a cargo type of body, bows and tarpaulin, with permanent cab over the driver's seat. The radiator is of the honeycomb type, bolted to the frame and braced to the dash as is common in American practice. The capacity of the radiator, water-jacket and pipes is 8 gal. The hood is carried on a special support directly back of the radiator instead of upon an extension of the latter.

The engine is of the conventional L-head type with cylinders cast in pairs and valves enclosed by cover-plates. It is bolted rigidly to a sub-frame, which also supports the transmission, the construction being virtually a unit powerplant inasmuch as the lower half of the crankcase and the lower half of the transmission case are bolted solidly together. This sub-frame is carried at the front end by the front frame cross-member, the rear end being supported directly back of the transmission case by the main frame. The crankcase is split horizontally at the crankshaft center-line. The timing-gear case is at the front end.

The right side of the engine is free of all attachments except the steering-gear and carbureter control rods that pass between the two cylinders and the carbureter which is located on the opposite side. The left side of the engine carries the exhaust and intake manifolds, the carbureter and the magneto, which is a Bosch unit and is placed just back of the timing-gear case. The shaft which drives the magneto extends through this case and drives the water-pump which is located in front of the timing-gear case. The water from the pump is led directly into the cylinder-head instead of into the lower part of the water-jacket as is the most common practice. This incoming water circulates directly past the valve pockets and out through a radiator connection placed at the forward end of the first pair of cylinders.

The fan is of the pressed steel type throughout and apparently mounted on plain bearings. The adjustment for this fan is by an eccentric stud mounted on the front cylinder block. The crankshaft is mounted on three bearings capped to the upper crankcase member. The pistons are considerably domed with four rings above the pin. The connecting-rod, camshaft, valves and lifters are of the conventional type. The timing gears are of the helical type; the crankshaft gear drives the camshaft gear which in turn drives the magneto and pump shafts. The governor is mounted in front of and is driven by the camshaft gear with a control lever connecting directly back of the throttle-valve of the carbureter.

The carbureter is a Pallace 1¾-in. type and is hung rather low down on the manifold because of the gravity system of gasoline feed used. The gasoline is carried in the main tank holding 38 gal. located under the seat. There is also a small reserve tank on the dash. The gasoline lines are of ¼-in. iron tubing. The steering-wheel carries a throttle-lever and there is also a foot accelerator on the floor-boards. The Bosch magneto is of the fixed-spark type, carrying no adjustment. The oiling system is of the conventional pressure type, pressure being supplied by a gear pump driven by helical gears from the camshaft. This pump is located at the bottom of the crankcase and forces the oil through the main bearings and through the hollow crankshaft to the connecting-rod bearings.

The clutch is of the cone type, is leather faced and equipped with a brake. The transmission has four speeds ahead and reverse. The case is split horizontally on the two shaft center-lines. The main shaft is four splined and the constant-drive gears are at the rear. All countershaft gears except the constant drive are bolted to countershaft flanges, the constant-drive gear being tapered and keyed. The shafts are mounted on D. W. F. ball bearings throughout, the inner races all being clamped between shoulders and nuts. The drive is transmitted from the transmission to the jack-shaft by a spider type universal joint.

The final drive is by jack-shaft and chains to the rear wheels. The jack-shaft is built up of five main parts, a torque tube extending to a cross-member just back of the transmission and being supported by a bearing on this member. This tube is flanged and bolted to the differential housing which is split vertically. The differential is of the bevel-gear type with hubs mounted on large annular ball bearings with ball thrust bearings at each side, the adjustment being entirely by shims. The outer jack-shaft bearing is of the annular type with a sprocket so cupped that the center-line of the chain is directly over these bearings. The reduction on high gear from the engine to the rear wheels is 14 to 1.

The steering-gear wheel is of laminated wood 15¾ in. in diameter on a cast spider. The steering lever is of rectangular section with a large stud bolted to it at the lower end. The reach-rod is of the pin-bearing type at each end and allows a very generous bearing. This rod is 1⅝ in. in diameter and about 30 in. long.

The front axle is an I-beam section forging and is of the reverse Elliot type with conventional spring-seats and clips. The rear axle is of rectangular section with spring-seats forged integrally, the axle section being 3 3/16 by 3⅞ in. To the rear axle is hinged a large pressed steel sprag which is suspended by a cable from a pulley attached to the frame. This cable extends to an operating lever on the front board of the driver's seat. The distance rod from the rear axle to the frame is of channel section with a threaded adjustment at the front end and a large ball-joint support over the jack-shaft frame bracket.

Bussing

This truck is of 2500-kg., approximately 2½-ton, capacity, shaft-drive type and equipped with the usual cargo type of body. The body has hinged sides and tail gate with steel channel bows bolted to the floor and supporting a canvas tarpaulin. The cab is permanent and is constructed of wood except for the cowl and doors, which are pressed steel. There are permanent glass windows in the sides and a permanent windshield with a movable section in front of the driver. The seats are upholstered in imitation leather. There are flat pressed steel mud-guards over the front wheels and a short steel running-board on the left side.

The radiator is of the vertical-fin type, the fins being approximately ⅛ in. thick and the width of the radiator. There are supplementary cooling fins placed between them. The radiator casing is made of four castings bolted to either side at the lower corner for the suspension. The fan has six pressed steel blades riveted to a cast-iron hub and driven by a belt from a pulley mounted on the crankshaft.

The engine is a four-cylinder type with the cylinders cast in pairs and supported by four arms which are integral with the lower half of the case, each arm being fastened with one bolt to the steel channel sub-frame. The valves are in the top of the cylinder and are operated by an overhead camshaft which is driven by a pair of spiral gears through a vertical shaft on the left side, between Nos. 2 and 3 cylinders.

The camshaft bearings are of plain bronze of generous proportions.

The lubrication is by a mechanical force-feed oiler mounted on the rear of the No. 4 cylinder and driven by a crank and ratchet off the rear end of the camshaft. This oiler has leads to the camshaft bearings and to the crankshaft bearings. A magneto and a water-pump are driven by a cross-shaft which is driven by spiral gears from the crankshaft. The pump delivers water through a manifold to each of the four cylinders at a point just under the carbureter and the intake pipe.

The carbureter is a 1¾-in. Zenith attached to a conventional type intake manifold, which has a priming-cup on top in the center. The hot-air pipe conducts the air for the carbureter from a stove placed on the exhaust pipe. The crankcase is split horizontally at the center of the crankshaft with breathers placed in the upper half at each left corner.

The clutch is a reverse action cone with a rather complicated release. The power is transmitted from the clutch to the transmission through a propeller-shaft with the universal joints at each end. The transmission is of the selective four-speed and reverse type. It is mounted on a three-point suspension. The reduction on high gear from the engine to the rear wheels is 22 to 1.

The final drive is by the bevel-gear rear axle which has a reduction of 4¾ to 1. The axle has two channel section steel combination torque and radius rods which are mounted on either side of the axle and to a frame cross-member just back of the transmission. The rear springs are held to the axle by four drop-forged spring clips and shackled to hangers at either end. They are 2¾ in. wide, 57½ in. long and have 11 leaves.

The gasoline tank is placed under the seat and the fuel is carried by gravity through copper tubing to the carbureter. This tank has a capacity of 25½ gal. There is also an auxiliary tank of 3 gal. The foot-brake at the rear of the transmission is the internal-expanding type and is cooled by water supplied from a tank mounted upon the dash. The hand-brakes are of the internal-expanding type and mounted on the rear wheels. They are 2½ in. wide and 16 in. in diameter. A sprag is mounted on the axle under the springs on either side and operated by a cable from the driver's seat.

The steering-gear appears to be of the worm-and-sector type with an 18-in. plain wood wheel. The distance-rod is of the ball-and-socket type and is 1⅝ in. in diameter. The front axle is of the reverse Elliot type of rectangular section 2 1/16 in. wide by 2⅜ in. deep with the spring seats integral. The front springs are semi-elliptic, shackled at the rear end and pinned to the frame brackets at the front end. They are 43 in. long and 2⅜ in. wide and have 9 leaves.

The wheels are of steel with spokes of oval section with pressed-on tires of German composition rubber. The frame is of hot-rolled commercial channel steel with six cross-members. The frame brackets are of castings and there are no provisions for towing-hooks or drawbars.

Daimler

This truck is a 4500-kg., approximately 4½-ton, shaft-drive type vehicle equipped with the usual cargo type of body. The engine has four cylinders with valves in the head and the cylinders cast in pairs, the water-pump, magneto and carbureter all being located on the left side of the engine. The ignition wires are carried through a tube which is bolted to the cylinder-head. The timing-gears appear to be in the center of the engine. Apparently the camshaft gear drives the magneto shaft gear and it in turn drives another immediately beneath it which drives the water-pump. This pump is of the centrifugal type with a manifold extending to the left side of the cylinder walls. The magneto is a Bosch and is placed directly back of the gearcase just described. The magneto shaft is extended to the front and carries the fan driving pulley. The governor is mounted in a covered case in the front of the crankshaft. The pistons are slightly domed with three rings above the pin. This pin is split and is expanded into the piston by taper plugs. These plugs are hollow and are easily removed by a tapping through from one end to the other. The gasoline tank has a capacity of 33 gal. and is located under the front seat. Pressure is required to force the gasoline to the carbureter.

The radiator is the honeycomb type with a sheet metal shell and is supported on the frame by large trunnions at the bottom. A channel guard protects the front of the radiator and is braced back to the frame. No bumpers are supplied. The fan is of the pressed steel type and is carried on ball bearings.

The transmission is of the four-speed type with the secondary shaft underneath the main one. The drive is indirect, being taken from the lower shaft. The main shaft is the four-splined type with sliding gears bolted to the sliding members. The case is fastened to the frame at the four points. The final reduction from the engine to the rear wheels is 14 to 1 on high gear. The foot-brake is the external-contracting type placed at the rear of the transmission.

The rear axle is of an internal-gear-reduction type. The hand-brakes are located on the rear wheels and are of the internal-expanding type. The front axle is of I-beam section with Elliot-type steering-knuckles. The steering connections are of the usual ball-and-socket type. The front springs are semi-elliptic, 39⅜ in. long by 2 in. wide, and are made up of 12 leaves. The rear springs are also semi-elliptic, 58½ in. long by 2¾ in. wide and are shackled at both ends. The wheels are steel castings with circular-section spokes. The tires are of steel with wood fillers, single in front and dual in the rear.

The frame is of pressed steel channel section of a rigid type with four heavy cross-members strongly riveted to the side rails.

Horch

This truck is of 3000-kg. capacity, approximately 3 tons, and a shaft-drive type. In a test of this truck in Germany by Lieut.-Col. Arthur J. Slade the gasoline consumption was at the rate of 12.8 ton-miles per gal. The radiator is of the honeycomb type attached to the frame by trunnions and with no other support except the hose connection and the hood. The radiator is protected by a channel section guard strongly braced and of a contour similar to that of the radiator. The front wheels are covered by curved fenders and splash aprons similar to those used in touring car practice. From these running-boards are carried back to the rear springs and from there a small curved fender extends up to the body.

The engine is a four-cylinder L-head block type. The crankcase is split horizontally at the crankshaft center-line and the timing-gears are at the front end. The right side of the engine carries a 1½-in. Zenith carbureter bolted directly to the block and from this the mixture passes through the cylinder casting to the intake-valve on the left side. There are two hand-hole plates in the crankcase, each carrying a breather pipe. Within the timing-gear case on its front side is the centrifugal governor. The left side of the engine carries the exhaust manifold with its stove for heating the intake air. Between the engine and the frame is a large mechanical oiler, and the Bosch magneto is located directly back of the timing-gear case, being driven by a shaft from this case. The water-pump is located in front of the timing-gears and is driven from the same shaft that drives the magneto. The pistons are flat topped with three rings above the pin and one wiper ring below.

There is a large four-bladed fan, which has ball bearings mounted in an eccentric sleeve. This provides for tightening the drive chain. Silent chains are used in the timing-gear case. The oiling system is probably force feed to main crankshaft bearings with splash feed for the connecting-rods and the cylinders. There are baffle-plates which limit the amount of oil splashed into the cylinder.

The clutch is the conventional cone leather-faced type with springs that are not enclosed. This clutch is apparently carried entirely on the crankshaft extension and the drive is carried to the transmission through two enclosed universal joints and a sliding sleeve. The transmission is of the barrel

type with the bearings held in bolted-on cages. It is of the four-speed type with the constant-mesh gears in the front end, and all gears are of generous width. The main shaft is square and the sliding members are bolted to flanges, as are also the secondary shaft gears. The shafts are mounted on ball bearings throughout.

The foot-brake is located just back of the transmission and is of the internal-expanding type. This brake is metal-to-metal with the water-cooling arrangement controlled from the dash. Surrounding the foot-brake is a large pressed steel cross-member and supported by this is a yoke which carries the front end of the axle torque tube. Within this yoke is a universal joint that carries the front end of the drive shaft. The entire rear axle is built and braced together so that it acts as a unit, all thrust being through the yoke referred to. The drive shaft is carried back to a bevel pinion which engages a ring gear. A differential is mounted in this gear and carries at each end a small spur pinion. These pinions engage large spur gears on the axle shaft beneath. These axle shafts are supported in the axle tube and to their outer extremities are keyed the rear wheels. The axle is a double-reduction type with the last reduction in the housing. The rear axle reduction is 14 to 1. The hand-brake is of the internal-expanding type, mounted upon the rear wheels and operated through an equalizer. The gasoline tank is of 38-gal. capacity and located under the seat. Pressure, supplied by a pump driven from the camshaft, is used to force the gasoline to the carbureter. This pump is supplemented by a small hand-pump on the dash. The carbureter is controlled by a hand-lever on the steering-wheel and by a foot accelerator on the floor-boards.

The steering connections are of the ball-and-socket type with the joints covered by leather boots. The front axle is of the reverse Elliot type, of rectangular section with built-up steering-knuckles. The wheel spindle is bolted to the knuckle and its center line is considerably back of the knuckle-pin center line. The front spring is semi-elliptic, 39 in. long and 2¼ in. wide with 11 leaves. The rear springs are semi-elliptic, 54 in. long and 3 in. wide with 11 leaves. The rear springs are shackled at each end. The front and rear wheels are of cast steel with circular-section spokes. The spring shackles and all steering connections are lubricated by oil-cups rather than grease-cups. The frame is of pressed steel and of a flexible construction.

Dux

This truck is a 3000-kg., approximately 3-ton, capacity, chain-drive type vehicle, equipped with the usual cargo type body with bows and tarpaulin. In a test conducted in Germany this truck showed gasoline consumption of 9.67 ton-miles per gal. The front of the hood is supported by a channel element mounted to the frame directly back of the radiator.

The radiator is of the honeycomb type with pressed steel outer shell. The capacity of the water system is approximately 11 gal. The water-pump is of the centrifugal type, driven by a cross-shaft mounted upon the front end of the engine. This shaft also drives the magneto, which is a Bosch ZU4.

The engine is a four-cylinder L-head type, 4 5/16-in. bore by 6-in. stroke, the cylinders being cast in block with the intake passages from the carbureter carried in the block. The carbureter is bolted to the right side of the engine with a cored passage leading across the block to the manifold. There is also a passage through the cylinder block which conducts the heated air from the exhaust manifold heater to the carbureter. The gasoline tank is located under the seat and carries 27 gal. Pressure is obtained from the exhaust to force this gasoline to the carbureter, which is carried rather high on the engine.

The clutch is of the usual cone type lined with asbestos composition material instead of leather. The transmission is of the four-speed forward and reverse selective type, trunnioned at the front end and bolted at two points at the rear. The universal joints on the propeller-shaft are all the steel disk type.

The front axle is of I-beam section with spring-pads forged integrally. The wheel bearings are plain bronze bushings, 2⅜ in. inside diameter. Front springs are semi-elliptic with auxiliary springs at the end. The foot-brake is located on the drive shaft back of the transmission and is water-cooled. This brake is 13½ in. in diameter by 3¾ in. face and is of the external-contracting type. The hand brakes are located on the rear wheels and are 17¾ in. in diameter by 3 in. face and of the internal-expanding type. The wheels are cast steel with spokes of oval section, six spokes in the front wheel and eight in the rear. Tires are steel with solid wood, approximately 2 in. thick between the tires and the wheel.

The frame is of pressed steel with five cross-members. The side channel is 6⅝ in. deep. The frame brackets are cast steel or malleable iron of generous proportions.

Komnick

This truck is of 3000-kg. capacity, approximately 3 tons, chain-drive type, equipped with the usual cargo body. The very large honeycomb type radiator is back of the engine over the flywheel and is bolted to the frame through reinforcements brazed to the bottom of the shell. Felt pads are used between the shell and the frame. A three-bladed fan is mounted between the radiator and the dash and is driven by a belt.

The front axle is an I-beam section with Elliot-type steering-knuckle. The front springs are semi-elliptic, 36 in. long, and 2⅜ in. wide with 7 leaves. They are held to the axle by a large plate bolted over them. The steering connections are of the ball-and-socket type throughout. All wheel bearings are of the floating bronze bushing type, the front bearing being 2 3/16 in. inside diameter and 2 7/16 in. outside diameter.

The engine is a four-cylinder T-head type, with cylinders cast in pairs, and is supported by two integral arms at the front and a single bracket bolted to the case at the rear. A 1⅝-in. Zenith carbureter and a Bosch magneto are mounted on the right side of the engine. The governor is located in the intake camshaft gear. The crankcase is of cast iron split horizontally at the crankshaft center line. The timing-gear case is also cast iron with the oiler housing cast integrally.

The transmission is a four-speed selective type with final reduction to the rear wheels on high gear of 12 to 1. The transmission is supported at four points. The rear axle is an I-beam drop forging with the spring-seats bolted on. The floating bronze bearings in the rear wheels are 2 3/16 in. inside and 2 7/16 in. outside diameter.

WORK OF AERIAL FOREST FIRE PATROL

IN the 6 weeks ended Aug. 2, 1919, the aerial forest fire patrol discovered fifty-six fires in the California forests. All of these blazes were reported promptly and were quickly extinguished, thus preventing serious damage to the standing timber. Three flying stations are maintained and corps of aviators have made 373 flights over these wooded sections of the State. The distance covered on these trips according to the Director of Air Service, was 45,376 miles and the actual time the planes were in the air was 38,545 min. or approximately 27 days of 24 hr. each. In addition to the airplane patrol the Army balloon school at Arcadia, Cal., assisted in this fire detection work.

British Civil Aerial Transport

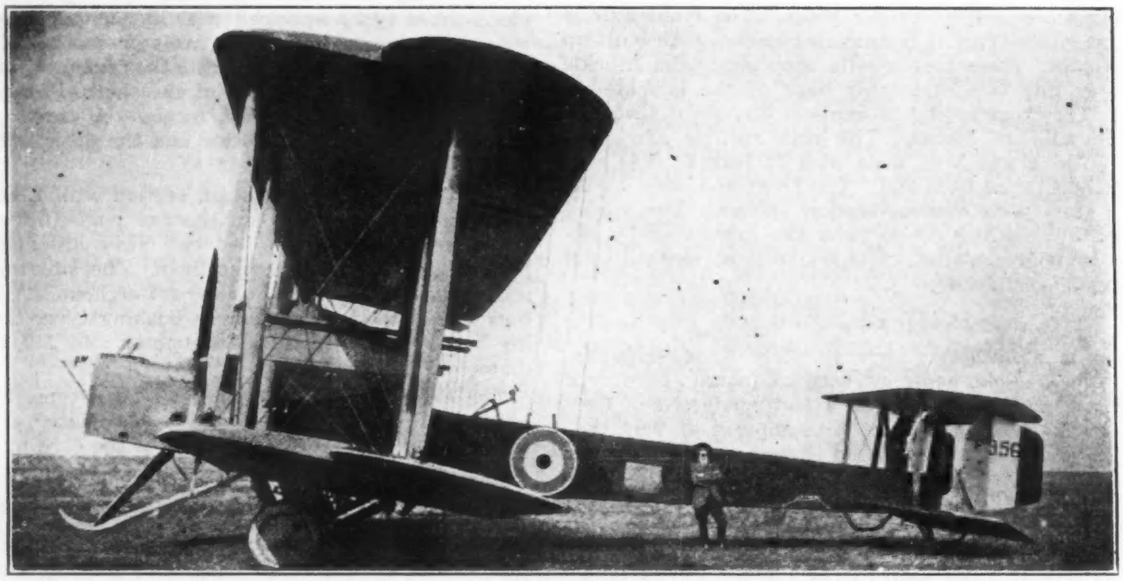
By C. G. Grey[1] (Non-Member) *Illustrated with* Photographs

DESPITE all the attempts which have been made of late to hustle the Air Ministry into issuing prematurely an immature set of regulations to govern civilian flying, one cannot help thinking that, after all, it is a very good thing that civilian flying has been restricted for so long. If it had been permitted yesterday, or if it had been permitted a couple of months ago, the great British public would have expected commercial aviation to burst forth in full bloom on the very first day that the official embargo on private flying was removed. The trouble is that the public can grasp a general idea readily enough but will seldom trouble to grasp details. Consequently, although a certain liveliness in civilian flying would have broken out as soon as the regulations came into force, the public would have been grievously disappointed at the small amount of that liveliness, for it would have no idea of the vast amount of detail work to be done before commercial aeronautics can get fully on the wing.

Great air lines, with their vast organization of landing grounds, harbors, signal systems, wireless stations and their equipment of specially designed airplanes with their crews of mechanics, cannot spring into existence parthenogenetically, as Minerva sprang full armed from the brain of Jove. And it takes time even to alter existing war airplanes into a form suitable for mail carrying or for the humble "joy-ride." Swords are not beaten into ploughshares in 5 min., especially when there is a coal strike in the offing and it is necessary to economize fuel. Therefore, it is just as well that the Government has not been in too great a hurry to make flying free for all, since, thanks to the delay, the aircraft industry has been saved from the jeers of a disappointed public. To tell the truth, hardly anybody is anything like ready to start civil aerial transport on a big scale even today.

As things have turned out, however, the aircraft industry is getting a chance to prepare for the transport of passengers; and, moreover, there is a reasonable chance that when flying is made free to civilians not only will the new regulations have been beaten into a sensible shape, but that the weather will have improved sufficiently to give airplanes a fair sporting opportunity to prove their worth as vehicles for regular traffic. It is true that when there is urgent need, as during a big battle, an airplane can fly in any weather—black darkness, pouring rain, a dense fog, or a howling gale—but pilots are not going to risk their lives, nor are firms going to risk their machines, for the sake of merely advertising flying.

Most people who read the papers have seen pictures of the "Pullman" Handley-Page biplane, with its central corridor saloon, armchairs, electric lights and triplex glass windows, and one can scarcely doubt that there are some thousands of people anxiously waiting for the chance of a ride in it. The same newspaper readers are equally familiar with the De Haviland-Four biplanes, which have been converted into nice cozy little saloon carriages for two, and were used to convey officials from London to the Peace Conference in Paris. Quite as familiar are the less elaborately converted De Haviland Nine and Nine A, which are being used for postal work between Folkestone and Cologne, and were to be used to export woolen goods and food to Belgium. Thus far, these are about the only British airplanes for civil aerial transport which have been made familiar to the public at large.



A Vickers Vimy Bombing Plane Equipped with Rolls-Royce Engines, One of the Most Promising Types for Civilian Use

Machines Available

There are, however, many other very promising airplanes of widely differing types which are either actually flying today or are about to fly in a very short time. Incidentally, it is well to note here that no Government regulation has in any way hindered the flying of experi-

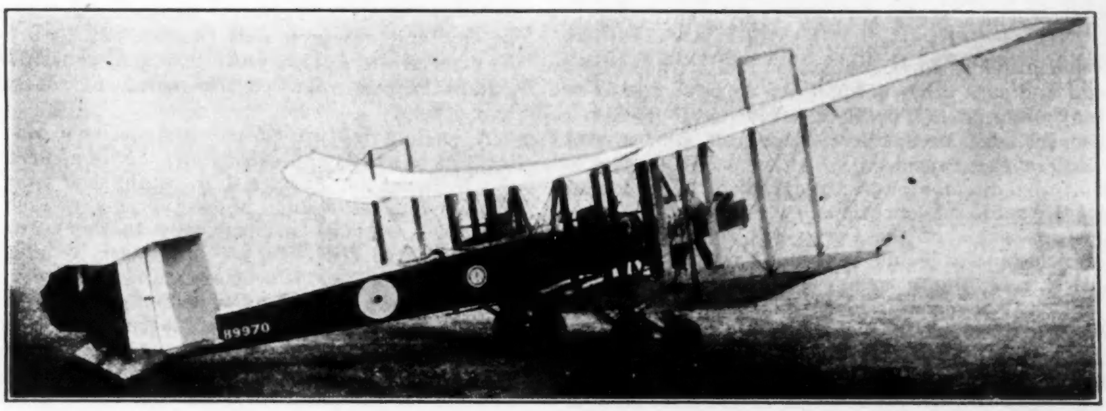
[1]Editor, *The Aeroplane*, London.

mental civilian airplanes since the signing of the armistice. Practically everybody who is capable of designing and building an airplane, and some who are not, have been engaged on such work during the war, and so already had the necessary permits to design and build. All who have built experimental machines have already had permits to fly them for experimental purposes. The aircraft industry has had no quarrel with the Air Ministry on any of those scores and has merely grumbled mildly because it has not been quite sure what restrictions were going to be put on flying in the future.

Among the most promising of the machines which have already been tried as war machines and are suitable with very small alterations for civilian use, are the Bristol-Braemar triplane and the Vickers-Vimy biplane. The former is a four-engined machine designed and built by the British & Colonial Aeroplane Co., Ltd. of Bristol. It has a power plant of 1600 hp. and a speed of something like 120 miles per hr. The machine measures 89 ft. from wing-tip to wing-tip, but the Royal Air Force officer who has put it through its tests says that, despite its size, it handles as easily as any machine of ordinary size. The Vimy is the work of Vickers, Ltd., the famous armament firm, and is considerably smaller than the Braemar, having a wing-span of 67 ft., but with two planes only instead of three and two engines instead of four. Several of this type have been tried with Rolls-Royce engines giving 700 hp., with Hispano-Suiza engines giving 400 hp., and with Fiat engines giving 600 hp., and it has performed excellently with all of them.

Another twin-engined biplane which has been giving very good results is the Blackburn Kangaroo, built by the Blackburn Aeroplane & Motor Co., Ltd. of Leeds, one of the oldest aircraft firms in the world, for Robert Blackburn began his experiments in 1908. This machine somewhat resembles the smaller Handley-Page in general lay-out and size but has a wing-span of 75 ft. instead of the 90 ft. of the Handley-Page. Although a land-going machine, it was used considerably for coast patrol work out at sea in the last few months of the war and acquitted itself very well. With purely minor alterations, it is immediately adaptable for passenger traffic, and a good deal should be seen and heard of it ere long.

There are many other British airplanes, especially flying boats of large size, either actually in use today or almost ready for their experimental flights, which are eminently suitable for passenger work. British workmanship in all industries has long been recognized as the finest in the world, and in no branch of engineering is finer work done than in the aircraft industry. Not only are British aircraft fully up to this historic standard of workmanship, but the designs are far ahead of those of any other country.—*The Illustrated London News.*



A Twin-Engine Biplane Easily Adaptable to Passenger Traffic

NEW LABORATORIES OF BUREAU OF MINES

THE new laboratories of the Bureau of Mines at Pittsburgh will be dedicated Sept. 29 and 30 and Oct. 1. Although intended to cover the general needs of the mining and allied industries, it is expected that the new plant will make it possible to devote considerable time to the problems that continually arise in the oil industry. They are, it is stated by the Department of the Interior, perhaps the best equipped in the entire world to undertake important oil research. The petroleum laboratory is maintained in one of the greatest industrial centers of the country and likewise one of the greatest research centers for the benefit of producers and consumers of petroleum products. The problems studied vary over a wide range, and include such extremes as a determination of the basic physical and chemical properties of petroleum hydrocarbons and the comparison of the quality of marketed products. Particular attention is being given to the improvement of methods of analysis of petroleum. This work is conducted with the idea of getting results of maximum practical importance. The Bureau attempts to develop methods which can be used in other laboratories besides its own and does not consider an analytical problem solved until results are of real practical value.

One of the lines of development concerns electrical devices for use in petroleum laboratories. These devices have numerous advantages, one of the most striking of which is the reduction to a minimum of fire hazard. The Pittsburgh laboratory has in the course of thousands of experiments with volatile inflammable products in the last 5 yr. had only two fires, neither of which lasted more than 2 or 3 min. and which did no damage. The types of heating equipment used by the Bureau are not yet generally available to the petroleum industry, but progress in this direction is being made.

Among the recent investigations of the Pittsburgh laboratory may be mentioned a study of the vapor phase cracking reaction for the production of gasoline from heavier oils, an extensive study of the problem of fuels suitable for high-power airplane engines, an investigation of the quality of gasoline marketed throughout the country and a number of investigations pertaining to analytical methods. It is announced that it is the intention of the Bureau of Mines to have its petroleum laboratory the center of oil research for the entire industry. Problems of general interest to the trade will, of course, receive attention first.

FUTURE OF THE AIR SERVICE

JUST what is to be done with the Air Service is at present somewhat problematical. Three bills dealing with this subject are now before Congress for consideration. One introduced by Senator New of Indiana provides for a department of aeronautics under the control of a director, while another introduced by Congressman Curry calls for the establishment of a department with a secertary to be a member of the Cabinet, and yet a third, sponsored by the Secretary of War, provides for a regular Army and a military air service.

The New bill provides for combined control of the military and the naval and such other aeronautics departments as the President may designate. The Post Office Air Mail Service is not to be included except in a more or less advisory connection unless the President so orders. While the bill mentions that the director shall have charge of civil aeronautics also, the subject is mentioned without detail.

Under the provisions of the Curry bill the proposed department of aeronautics would be headed by the Secretary of Aeronautics, receiving a salary of $12,000 and an assistant at $5,000. A commissioned personnel of approximately 5000 and a non-commissioned personnel of approximately 50,000, together with a large number of civilians to carry on the commercial work, is proposed. The aviation section of the Signal Corps, the division of military aeronautics, the Bureau of Aircraft Production and the Army Air Service would be transferred to the department, together with the Motor Transport Corps, Naval Flying Corps, Marine Corps Flying Corps and the Air Mail Service. It would be the duty of the new department to foster, develop and promote all matters pertaining to aeronautics, including the purchase, manufacture, maintenance and production of aircraft for the United States, and to lay down rules and regulations to govern aviators and aeronautics in general. The department would establish and supervise aerial landing fields for both military and commercial purposes and care for the coast, border and forest reserve patrol. An aeronautic academy is contemplated. The engineering division, under the direction of the Secretary of Aeronautics, would select types and designs of all aircraft equipment, including ordnance and communicating equipment, and conduct the repairing and maintenance thereof. It would operate and maintain aircraft factories, repair shops and experimental stations. Development of aerial apparatus with which photographic maps of the United States and its territories would be made is provided for.

The bill sent to Congress by Secretary of War Baker provides for the creation of a regular army to have a military Air Service of approximately 24,000 officers and men. In this case the Air Service would be a detail organization rather than a separate organization as provided in the two other bills. If this program is followed all officers for the Air Service will be men detailed by the President from the infantry to the Air Service. These details will be for a 4-yr. period and upon the completion of this assignment the men will be returned to the infantry for 2 yr.

Report of American Aviation Commission

The American Aviation Commission, which, under the leadership of the Assistant Secretary of War, made a study of extended scope in Europe recently, has recommended the concentration of the air activities of the United States, military, naval and civilian, within the direction of a single Government agency created for the purpose, coequal in importance with the Departments of War, Navy and Commerce. It is the view of the commission that the agency thus created should be charged with full responsibility for placing and maintaining our country in the front rank among nations in the development and utilization of aircraft for national security and in the advancement of civil aerial transportation, communication, etc.

The commission was composed of both Government and industrial representatives and its conclusions and recommendations should have great weight in the determination of the future of the Air Service, inasmuch as a logical and very forceful plan has been worked out by it after an amount of investigation equal to any that has been made by a body representing this country. The commission has recommended that there shall be a civilian Secretary for Air and a civilian Assistant Secretary responsible for the management and operation of the Department, which would be divided into five or more sub departments specializing respectively in civil aeronautics, military aeronautics, naval aeronautics, supply and research and finance. It is urged that there be formed an Advisory Air Council, constituted of the Assistant Secretary of Air, the chiefs of the subdepartments, and others.

A leading feature of the commission's plan is the circularization of Army, Navy and civilian personnel through the National Air Service to be established as indicated above. This personnel would, unless permanently assigned to air work, be returned automatically to the military and naval sources or to civil life, as an air service reserve, after the expiration of the educational and service periods in the National Air Service. It is felt that such a circulative system is vital to the coordination and ultimate efficiency of the three services and to the desired dissemination of interest in and knowledge of aeronautics. This would make possible the direction of civil and commercial activities of all kinds, and assure the closest contact and cooperation between the Government and the aeronautical industry.

Under the plan of organization recommended all squadrons and all equipment assigned by the National Air Service to meet the stated requirements of the military and naval establishments will pass automatically under Army and Navy command, only those independent projects unrelated to the activities of the military and naval fighting forces and such personnel and equipment as form a surplus to the needs of the sea and land fighting arms remaining under National Air Service operational direction.

The advantages of establishing a Department of the Air are believed to outweigh any temporary difficulties. If our aircraft activities remain dispersed among several Government departments and impossible of coordination or decisive action, it will be impossible for the nation to secure the full benefit of active and sincere cooperation in the engineering phases and in the scientific and commercial aircraft developments with those countries with which we were associated in the war.

It is stated in the report of the commission that Great Britain, France and Italy are maintaining their aeronautical technical divisions at war strength in equipment and personnel. The commission has recommended that the research, experimental and development facilities and equipment now used in aviation by the Army and other Government departments be put under the control of a centralized technical division, great care being exercised to guard against measures which might interfere with suggestions for improvements and advances in aviation coming from the operating branches of the Army and Navy and the Post Office Department. It is felt that the technical division should maintain and encourage a number of private plants, cooperating with them in all undertakings meeting the approval of the division and placing orders with the plants for design and for experimental construction of engines, planes and appliances. It is recommended that the technical division shall carry on all investigations and tests of experimental construction and revision and issue certificates of air-worthiness of machines for private and commercial use and also inspect all machines and appliances used by the public. The technical division would, in cooperation with the civilian division, have power to limit and control the types of air machine used in commerce, testing them before they become production models. The commission advises that close cooperation be maintained with the aeronautical engineering and industrial organizations in order that standardization of materials and practices can be carried on as rapidly as possible without hindering the development of the art.

Addresses at the Tractor Demonstration Dinner

ON the evening of July 17 an S. A. E. Tractor Dinner was held at the Hotel Lassen, Wichita, Kan., in connection with the national tractor demonstration that week. Past-president C. F. Kettering was toastmaster. The other speakers were the Hon. Henry J. Allen, governor of Kansas; E. J. Gittens, vice-president of the J. I. Case Threshing Machine Co.; John Fields, editor of *The Oklahoma Farmer;* Prof. L. W. Chase of the University of Nebraska, and Mr. Hale, county agent of Chase County, Kan.

ADDRESS OF PAST-PRESIDENT KETTERING

THE Society of Automotive Engineers is supposed to contain all the brains of the automotive industry. The automotive industry has to do with self-propelled vehicles of any kind, whether motor boats, automobiles, tractors, trucks or airplanes. Anything that moves by power other than animal power is automotive. Our organization used to be the Society of Automobile Engineers, but the automobile people realized that there is wide use for the internal-combustion engine. We have begun to realize that we are living in a modern time in which progress, so far as this earth is concerned, depends upon the use of power external from man and external from animals.

I believe that none of us realizes to what a tremendous extent the common old gas engine has entered into our lives. It is transforming every type of human industry. In the war it was the army mule, it was the eyes of the army, it was the transport, it was the submarine, it was everything where we used power.

Future of Agriculture

We are gathered in this city for a demonstration of what the application of that peaceful apparatus is doing and can do for the furthering of agriculture. Agriculture is just coming into its own, and I believe that it is safe to say that the next hundred years in this country will be known as the Agricultural Age. Engineers have felt that it is rather a step down to put their time, skill and engineering ability into designing farm machinery. I believe they now realize that there is a wonderful opportunity in this not only from the commercial side but from the standpoint of the development of this country as a great power.

Agriculture, the most fundamental of our industries, has had less attention scientifically than any other of the tremendous industries of which we know. Therefore, it is a wonderful thing to find assembled in a city of this kind a group of men whose attention is centered upon the mechanical side of this agricultural business. It has not been touched yet. We have not even scratched the surface because we do not know to what a tremendous extent mechanical farming is coming. We do not appreciate the enormous scope of our country. We do not appreciate the varied conditions under which agriculture proceeds.

We had an opportunity the other day in coming here to fly over three or four states and could tell a lot about the character of the people and of the whole community by simply getting the bird's-eye view of the country over which we passed. Unless we as engineers designing apparatus for this wonderful industry can appreciate more of the conditions from Maine to California, we shall fall short of comprehending our real duty. It is a task to design a piece of machinery that will operate under all of the different conditions. It is only by meetings such as this, by demonstrations, by getting together, that we will ever comprehend fully the problems we have before us.

I wonder whether we all realize that we are passing now into a new industrial and economic condition in this country. Too many of us, I feel, are prone to go back and take a reckoning from our pre-war conditions and try to project it into the near future. In the two years of the conflict the whole world method of thinking slipped as a great fault in a rock. It is impossible for us to project from our pre-war experience into the future. We must get together, start a new base-line and take into consideration a great many new factors.

In the first place, through the mobilization of our troops we have transferred from one section of the country to the other new lines of thought. The boy of the West met the boy of the East; the boy from the North met the boy from the South; they all went over together in a common cause. They formulated a certain mental picture of the future and that is going to be reflected in our future developments. We have to form a new and greater conception of the things that are to come. We must have broader policy in every angle of business. The labor question must be treated on a broad basis; also manufacturing and the development of new ideas to give people more of what they want.

Our present labor difficulties are not so much due to the fact that men want more money and shorter hours; that is only the thing they are talking about today. What they want and what they need is a mental perspective, a definite understanding of their future and an appreciation that they can advance and develop. In other words, the day of the blind alley in anybody's mind is at an end. There is not a man, I do not care what position he is in, who, if he goes to his work day in and day out without a constructive picture of the future, is going to be satisfied. A reasonable amount of constructive education is necessary.

We talk about Bolshevism. We have allowed the foreigner to come to this country and become educated on the streets and in the saloons, and we all stand ready to pass him in condemnation for his attitude. If we had exerted slight energy to educate that fellow, to give him some conception of our American Government, we would not have him as a problem. We must all broaden out and take a new conception of this whole thing.

Local Demonstrations

I spent this forenoon out at the demonstration field. I have attended, I think, every national tractor demonstration that has been held. I wonder whether, in the development of the tractor industry, we have not almost reached the point at which the enormous expenditure of money and time for these field demonstrations is no longer justified. I believe that there is no question in the mind of anybody today as to the utility of the farm

tractor. I believe that these demonstrations should be made more local. I do not know what a demonstration on these level fields of Kansas would mean to an Ohio farmer, but I do know that it is as important for an Ohio farmer to have a tractor to plow and till his land under the conditions he has to work with, as it is for the Kansas farmer. I believe that an equal amount of money spent on constructive local education, upon service and upon those things which tend to form and to build a fundamental foundation for the industry would be better. I am not advocating a discontinuance of field trials.

The automotive industry is doing wonderful things. It is giving to man for the first time in the history of the world a detached power unit of considerable size with

—Photo taken by Past-Councilor E. S. Foljambe

PAST-PRESIDENT KETTERING ALIGHTING FROM THE AIRPLANE IN WHICH HE FLEW FROM DAYTON TO WICHITA

which he can perform a great many of his duties. This unit is yet in its infancy. No one with the greatest imagination could predict the possibilities of the automotive industry.

We did not come from Dayton to Wichita by air to try a stunt, but because the modern airplane is capable of making the trip and because people did not know that such a thing could be done. The airplane industry is here, but people do not know it, and you, regardless of what your opinion may be of keeping both feet on the ground, are going to get up in the air. You are going to fly, not because you want to but because in the future the economy of business application will make it as necessary for you to fly as it was necessary for you to drop the horse and buggy and take to an automobile. This is only one of the phases of the great scientific development that is coming in this country. We must accept it with an open mind. There is nothing in the world so inert as the human mind. It does not want to change; it does not want to be rooted from the position which it now holds.

We do not think of the airplane as important today because but few know its wonderful possibilities. Permit me to tell you an incident. I had to be in Philadelphia Monday. I left there Monday night on a fast Pennsylvania express that goes to St. Louis. I got out at Dayton shortly before eight o'clock, went home, had breakfast, repacked my bag, went down to the field, got into an airplane and we were in Wichita, Kan., two hours before that train was in St. Louis. I do not care what you think about flying or about the airplane; there is an economic fact which all the skepticism of the world cannot push aside.

ADDRESS OF GOVERNOR ALLEN

I THINK you have done more toward revolutionizing the agricultural world of the future than any other men we have. We are all farmers tonight. I remember my own farming days and compare them with the present era. What you have accomplished is little less than miraculous. I remember I was the humblest instrumentality of the agricultural world. I was a hired boy on the farm, which meant that I did a man's work in the field at a boy's wages, and then, being just a boy, I did the chores while I was resting. In my day, when we went out to plow a field we walked between the handles of the plow, or if we harrowed the field we walked behind. If the farmer was not watching sometimes we stole a board and put it on the harrow and rode until he caught us at it. There was no dream in anybody's mind that in this world things would ever be easier for the farmer, and here you marvelous wizards come out of your experimental stations and your laboratories and show him that already the horse is an unnecessary thing to have around the farm.

I am very glad indeed that you men representing this thinking and creating power have come to Kansas. There are two sciences, the science of invention and the science of psychology, and I think it is very important that you come here to the field that needs your endeavor in order that you may understand the psychology of the farmer and understand not only his needs but what his idea of his needs are, because you may lead him into broader paths.

LABOR TO RECEIVE CONSIDERATION

You have come in startling fashion upon an old world to turn men into broader paths of usefulness, and it would not be fair to the new condition you hope to create if you did not give some consideration to the condition of labor that is to be affected by your scientific endeavors.

We are talking a great deal today about how the world is to be made over and many of us are worrying about the League of Nations and whether the Peace Table at Versailles created the proper condition. Let me tell you that the most important peace table in the world today, gifted with a potential power to lead as no other peace table can lead, is that table around which will gather in this new day men who employ labor and labor itself to agree upon a program of equity so that there may be contentment and happiness and plenty for all out of the marvelous productive period we are helping to create. If we do not go forward with a broad and helpful program along that line, the movement will be lop-sided. If anybody tries to sit on the lid in this country, there are going to be explosions just as there always have been

in countries where a few men sought to sit upon the lid that the benefits and privileges of life might belong to a few.

There is no danger of Bolshevism in this country. Yet Bolshevism is a very real thing in Europe. In this country it is merely an infectious word. It means whatever happens to ail you when you use it, but over there it is the definition they give to the effort of one class to march from autocracy to self-government, and every march that has been made from autocracy to self-government has been made along the pathway of sacrifice and suffering and bloodshed. We had it in this country, of course. The Civil War did not begin when Fort Sumter was fired upon. It began when a Dutch brig unloaded at Jamestown, Va., a group of gentlemen who called themselves Cavaliers. About the same time there was unloaded at Plymouth Rock another shipload of people who called themselves Puritans. These two groups planted upon the American continent two separate and distinct ideas, and ideas are the warriors of the world. One of these ideas was that a man had a right to worship God according to the dictates of his own conscience and that human labor was free. The other was that the white man had a right to buy and own the black man in industrial slavery. These two ideas began their mighty race across the American continent, each establishing institutions of its choice, one north of the Mason and Dixon line, the other south. In the great extent of territory there was room for a while for both institutions to grow, and then the continent began to fill up and the man who had landed at Jamestown and the man who had landed at Plymouth Rock began to jostle each other and each began to be aware of the presence of the other until conflict became irrepressible. Then God Almighty took these two factions and threw them together into the crucible of Civil War, and when the refining fire of four years' duration had burned out the impurity in our system, we were an amalgamated people and the day of Bolshevism was over for us forever in the United States.

When we went across the ocean to meet the call of the cause of free government, there went marching together the sons of the men who had worn the gray uniform and the sons of the men who had worn the blue uniform, and keeping step with them were the sons of the black men who had been set free in that final struggle on the American continent for absolute freedom of all men to labor according to their capacity and their ability.

Need for Many Owner Farmers

So we have come now, in a new day, out of the greatest spiritual adventure the American people ever entered upon. In leadership according to this new day we must take into consideration that very wise philosophy of the toastmaster that a man to be a good citizen must have perspective; he must be able to stand at one end of his life and see reaching into the future something for him except his daily labor and his weekly wage. You men who are going to make a new business of farming as well as a new business of everything else, remember that farming will still have to be done if we build here a great agricultural people by men who live upon their own farms and till the soil. You may make it easier for them, make it very much easier to have farming become a great commercial enterprise with farms operated in large tracts, but the thing the world needs out of an agricultural population is not large tracts of farming, but large numbers of farms owned by the men who till the soil.

I have seen the rising tide of Socialism in the past two years during which I have spent most of my time in France. I have seen it rise and break three times, driven though it was every time by the cleverest of German propaganda. Every time it broke, it broke against the land titles of France, because in France almost 90 per cent of the men who till the soil own the soil they till.

Here in Kansas we are seeking to find an answer to the problem in a Constitutional amendment which will be voted upon at the next general election, an amendment which will extend the credit of the State to every man who wants to own a small farm, because in this State, new as it is, already 50 per cent of the farm lands are owned by absentee landlords, and while many of those absentee landlords are men who have moved into town and left their sons and sons-in-law to take care of their farms and therefore do not represent an objectionable type, there are at least 30 per cent of those men on the farms who would like to own farms if they could get a start. So Kansas purposes to start a program that will give every worthy man who desires it a chance to own his own farm.

Among the things we are going to do, in addition to extending the credit of the State, is to relieve mortgages from taxation. Two-thirds of all the states of this Union today still hold to the archaic system of double taxation, represented in the taxation of the farms and the taxation of the mortgage. If the early legislators who made this program had been seeking to find a cunning device by which they might defeat the ambition of any poor man to own a farm, they could not have beaten the things they stumbled upon, because when a man who has not the money to buy a farm does buy, he pays taxes on the mortgage and taxes on the farm and interest on the mortgage; three times he is asked to pay and he cannot make it.

For the purpose of making possible a pleasanter life on the farm, Kansas will expend this year something like $19,000,000 for hard surface roads. Then after the next Legislature has met, if the people vote for the Constitutional amendment, we are going to increase automobile licenses and float a bond issue in this State of $50,000,000 and let the men who own the automobiles and use the roads pay these bonds. Every dollar of the money will be spent, along with all we can get out of the Federal Government, for more good roads, and in five years it will be difficult to enter a county which does not possess a modern hard road system which will link together the village and the town and the city and the farm.

ADDRESS OF JOHN FIELDS

FARMING is more than a business. It is a life as well. The condition existing in Kansas where, as Governor Allen mentioned, half of the land is farmed by men who do not own it, exists in Oklahoma and in all of the states. That situation has not been brought about because farming on the average has been unprofitable but resulted from the unsatisfactory living conditions in the country, having to do with just the things that you men are supplying and one other thing.

Bringing Comforts to the Farms

Automobiles, tractors and farm lighting plants bring to the country home those same comforts which collectively are made available in a city such as this. The other job, and the one to which we are addressing ourselves industriously out here, is to equalize educational

opportunity in the country with that in the city. The people who have left the farm and whose places have been taken by tenants, four-fifths of them, according to an estimate of the United States Bureau of Education, moved to town to send the children to school. Country folks are human. They want for themselves and for their children just the same things that you men want. The things which will make for the welfare of this nation are just the kind of work which you are doing, which makes it possible to have more of the desirable things in the country.

Mention was made of the relationship between capital and labor. I would like to see farmers collectively admitted to full membership alongside of capital and labor in all of our considerations. Farmers represent the one unorganized but vastly important portion of our population, that portion which will be the last stronghold of individualism, because, after all, the ideal farmer is the farmer who is independent and self-reliant and fights things out for himself. He is the most difficult of all to organize. I plead with you men for a realization of the fact that it is just as much your business to look after the economic welfare of the farmers of this country as it is to adjust any differences that may come up between you and organized labor. Unless you do so represent it, it will not be represented and we will have a continual increase of discouragement among those who live on the land and farm it. It is the business of some of us to seek as best we may to represent this unorganized but vastly important mass of our citizenship and if in representing them we seem to do some things that do not quite fit in with your propaganda, keep in mind that the thing of first importance is that there be the greatest possible production at the lowest possible cost, and then from the point of view of both you and ourselves, that the farmer get all that he possibly can get for what he raises because he is the champion spender when he gets money. Ultimately you will be getting it.

Development of Crops

Kaffir represents one development of crops adapted to a specific region and you are in it now. Touching on the greatness of Kansas, and when I speak of Kansas anything bad that Kansas does Oklahoma does worse, Kansas is the greatest agricultural area in the universe. The last ten corn crops of Kansas were worth $180,000,000 less than it cost to grow them, according to the individual reports made by Kansas farmers to county assessors year by year. Certainly if this were not the greatest agricultural area in the universe, it could not do that kind of thing and get away with it and maintain the absolute evidence on every hand of prosperity of the greatest kind. The acre value of kaffir in Kansas for the last 18 yr. has been 36 per cent greater than the acre value of corn. We suffer in the United States because when people move from Indiana and Illinois to Oklahoma and Kansas they are still in the United States. If they moved that far in Europe they would be off the earth, and so we have to make them over, make over their methods, and it is some job!

There is just one particular point in connection with the methods that effected the change in Oklahoma that I feel might in some degree be applied by you. For 15 yr. the Kansas and Oklahoma Experiment Stations and the farm papers of this country pointed out and proved by experimental work and by the collection of actual definite results on farms that on a great part of the land planted to corn kaffir was the more profitable crop; yet after 15 yr. of that work we had only 500,000 acres of kaffir in Oklahoma. Finally we got this fact through our heads, that the men who controlled credits in an agricultural community determine what the farmers do, and we quit talking at farmers' meetings and proceeded to submit these kaffir facts to the bankers at their group meetings. Half a dozen groups of bankers met and the facts were told them, with the result that in 2 yr. we increased the kaffir acreage in Oklahoma from 500,000 to 1,500,000 acres.

That same thing applies in a considerable degree to the development of the tractor business. There was a time when the banker was not sold on the automobile. When he finally was sold, he was the most enthusiastic advocate of the use of the automobile among all of us. He is not particularly enthusiastic about tractors in many localities, but he is thinking about them and is studying them and you will influence and reach and make believers out of fifty farmers every time you make a tractor Christian out of a banker in this country out here.

ADDRESS OF PROF. L. W. CHASE

THE people of our State seem to question some of that good advice which there is in catalogs, and each farmer not being able to hire a consulting engineer to assist him in buying a tractor engine, our Legislature last winter put through a law which requires the University of Nebraska to test one model of every tractor that is sold in Nebraska. Some of you will doubt the advisability of such a law. I believe that it is going to aid the tractor industry materially. You men are designers and builders of tractors, but I doubt if many of you have had much experience with operating tractors. Otherwise you would change the seats on them.

I will give an illustration of some of the difficulties in tractor operation. Three farmers in our State bought one each of the same kind of small tractor. One farmer reported to me that he had plowed 300 acres with the tractor, the only trouble he had being to put in one or two new spark-plugs, but the other two men had not yet passed the 50-acre mark and thought their tractors were ready for the junk-heap and that they would need a team of horses to haul them to the heap.

Now we hope that this is not the fault of the design but of the operator. As a representative of an educational institution I might state that I feel that every educational institution connected with an agricultural college in the United States is exerting its forces to the limit to make the tractor a practical and economical machine for the farmer. Two years ago our institution put on a short course of 4 weeks and we had about eighty-five students. Last winter, in my absence, our boys put on three short courses of 1 month each and we had a total of 387 students. This year we feel the need of educating our farmers in the operation of their tractors to the extent that we are going to start our short courses Oct. 1 and run them until March 1, each one to extend a month and registration to commence the Monday of every week.

We have looked upon the educational line of our short courses a trifle differently from some other institutions, as we feel that the tractor industry will be stable if our operators are trained so that they can do their part, and for that reason we are putting on 1-month short courses in which men from the farms are giving all their time on tractor work.

Standardized Tractor Ratings

The tractor industry is probably less standardized from the manufacturing standpoint than any other industry or any other line of machinery that we have. I have plotted the cubic inches of piston displacement per horsepower required by each of 214 tractors. The figures vary greatly. I think the lowest is somewhat less than 9000 cu. in. per minute, and the highest over 18,000. That comes from computations of machinery supposed to be scientifically manufactured. I believe that something should be done to standardize the rating of your tractors, at least the rating of the brake-horsepower.

I have divided the tractors into a few groups, one with engine bore of less than 4 in., another from 4 to 5½ in., the next from 5½ to 7 in., and the last from 7 in. on. The small engines seem to be able, taking the ratings from your catalogs, to develop 1 hp. on less than 13,000 cu. in. displacement, possibly a little over 12,000; the medium sizes require about 12,640; the larger sizes less and the largest sizes much less. The peculiar thing is that there are tractors listed which have the same size pistons, the same length of stroke, the same number of cylinders, the same number of revolutions, and they have over 50 per cent variation in rated horsepower. I am not ready to say whether the man that is under-rated or the man that is over-rated is right, but that is what the figures show.

In tests I have made of twenty-five tractors many of the engines did not develop their advertised rated horsepower.

That is just one item that I think we all, as engineers, should think about. It is really a vital thing. In the State of Nebraska 5 yr. ago 167 per cent more power was used in the form of gasoline, kerosene or steam engines on the farms than was used in all manufacture and all power development processes, including mills, elevators, street-car lines, water systems, etc., so that in all this you will find that there is really some need of establishing some standardized tractor tests.

ADDRESS OF MR. HALE

Most farmers have the impression that tractors are made to sell and not to use. I know we are getting over that. The demonstration I saw today makes me believe fully that we are going to have a type of tractor that is suited to this farm or that farm, whichever type of farm it may be. You and I know that it is practically impossible to get a type of tractor suited to all conditions.

The county that I happen to be the county agent of being largely a pasture county, we farm in a small way. Few tractors are as yet used there. The possibilities of their use are great, providing the right kind of a tractor can be started in that county and started in the right way.

I was interested in a remark that a certain manufacturer of tractors made out on the grounds today, which was that this tractor is knocked because of the failure of some certain tractor. He said that the salesman failed to educate the operator of that tractor. Salesmen have merely collected the commission when they finished the deal.

Education of Operators Necessary

Education must come in such a way that we can depend upon operators of tractors to operate them as it is intended they should be operated. I am sure that the short course at the University of Nebraska and the work to be done at the Kansas Agricultural College at Manhattan and other State institutions will solve this problem to a great extent.

But I believe also in small demonstrations in the various counties. I believe that if I could arrange for cooperation with the various manufacturers of tractors in this group here, I could get in Chase County as large an audience as you had out here today for a 2-day demonstration. Every county agent in the State of Kansas can do the same thing. You would reach a larger percentage of men in this way, and I believe your experience would be more satisfactory and your expense far less. The National Tractor Demonstration should, it seems to me, draw a larger gathering of farmers than it is gathering. The farmer is entirely too busy at this time to come here to this show. If you demonstrate where he can jump into his car and come in, see what you are doing and talk it over with you, he will be there.

ADDRESS OF E. J. GITTINS

Having been in the tractor business or in the traction engine business practically all of my business life, I naturally have a few fixed ideas and convictions as to what a tractor should be. If I should summarize my ideas into the briefest possible expression or description of what that tractor should be, I should call it a practical quality tractor. By "practical tractor" I mean a tractor that is designed to do the things that it is intended for in a practical way, and there is a lot of difference between a tractor that is designed for appearance and for sale and one that is really for practical use.

I do not have in mind any particular form or type or style, any particular number of cylinders or any particular way in which those would be installed in the machine, but every part of the best quality and of the style or kind best fitted for the uses to which it must be put. I would emphasize the qualification that I make of "practical," by which I mean designed for the service it is intended to give as a money-maker. I doubt if anyone would appreciate the difference unless he had had actual experience with tractors.

Problems of Tractor Development

I would not belittle the importance of theory, because everything has its inception in theory, but the working out of the theory into a practical profit-making machine for the user is the difficult thing and involves a great amount of experience and experimentation. These problems are the ones in connection with the development of the tractor, especially, I say, to be considered wholly from the standpoint of the user. I think that is true, however, of all products.

The operations on a farm in raising a variety of crops are varied. The farmer who contemplates using a tractor has a vision or a mental picture of the conditions that prevail upon his farm in particular, which may be entirely different from those on even the adjoining farm. His land may be level and easy to till, it may be hilly, it may be clayey and hard, it may be sandy, it may have ashy soil, it may have any or some or all of these characteristics and yet that tractor must perform its duty under all or any of these conditions. It is not like an automobile. The problems are entirely different as I see it. An automobile is made and intended for use on roads, and the contemplating purchaser, be he farmer, business

man or one seeking pleasure, views the automobile in about the same light. The predominating qualifications are comfort, style and I must add service, of course, but the service is much easier than that of a tractor. The farmer contemplating a tractor must know that it will operate successfully at plowing or disking in the springtime when the ground is soft or even wet, it must do so in the midsummer when the ground is hard and dry, it must be able to furnish proper power for his thresher and his silo filler, it must be able to haul his binder or mower or spreader or any of the multiplicity of things that are used on a farm, and it must do all those things successfully to be a profitable purchase for him.

I say unhesitatingly that the problems and the working out of those problems successfully are incomparably greater and more important than those of almost any other farm tool.

I have said that I would emphasize the qualification of "practical," but I would emphasize still more the qualification of "quality." I feel that tractors cannot be made too good for the fearfully hard service they must necessarily withstand to be successful, to enable the farmer to raise more and better crops and with less labor; that is what it must do.

The national tractor demonstrations have served a good purpose, in my opinion. They have shown many of the uninformed that tractors will really perform successfully. Many who have been skeptical are not so now. I believe that the farmers are pretty generally sold on the idea of the use of the tractors. These demonstrations do not prove finally that tractors are a success or that they are a profitable purchase. It takes the work week-in-and-week-out to do that. It is the farmer who must use them to make money, to make a profit for himself and therefore for the rest of humanity. He determines that he is the final judge.

I repeat that in my opinion tractors are not and cannot be made too well and the sooner we who are interested in the making of them appreciate that we are either not now making them good enough to be sufficiently dependable or making the very best that we can with proper consideration for all of the problems surrounding them, the sooner we will have served ourselves and those who purchase them.

MEETING ON SECTION AND MEMBERSHIP MATTERS

AT a meeting held at the offices of the Society in July all but one of the Sections of the Society were represented either by officers thereof or by those in attendance who had been deputed by Section officers. The meeting was held for the purpose of combined consideration of Sections and membership matters. Those present were Joseph A. Anglada, John T. R. Bell, A. C. Bergmann, C. F. Clarkson, F. A. Cornell, H. D. Dabney, O. L. Formigle, C. C. Hinkley, J. L. Mowry, F. W. Parker, Jr., G. W. Smith, Jr., J. G. Utz and Austin M. Wolf.

The Manual prepared for the use of the Sections was considered paragraph by paragraph. The suggestion was made that the forms given in the Manual be adopted uniformally by the Sections and be supplied by the Society office. It was the sense of the meeting that the Governing Committees of the Sections should, prior to taking action on applications for membership in the Section or Associate enrollments therein, send the names of the applicants to the office of the Society in New York for verification as to membership in the Society. The logic of this is that only members of the Society are eligible for membership in a Section, and of course no one who is a member of the Society should be enrolled as an Associate of a Section, as a Section Associate does not hold membership in either the Society or the Section.

It is felt that the Manual will be helpful if studied and followed by the officers of the various Sections, and copies of it have been sent to all of the Section Governing Committees with the request that criticism and suggestions be sent in and finally submitted for acceptance. It was voted at the meeting that the Manual as amended thereat should be submitted to the Council for approval as the Manual governing the activities of all Sections.

It was the sense of the meeting that some restriction of the present privileges of the Section Associate should be attempted as a stimulus toward increase of valuable and creditable membership in the Society. The only privileges of the Section Associate at this time are substantially those of attending meetings and receiving THE JOURNAL of the Society. The Section Associate is not included in the membership roster of the Society, does not receive the Society's Data Sheets and Transactions, or certificate of membership, or the right to wear the emblem of membership. The restrictions upon the Section Associate enrollment that have been considered are limiting the enrollment for two years (that is not re-enrolling for one year more than once), permitting attendance at Society meetings as guests only and non-inclusion on the mailing list of the Society for THE JOURNAL.

It was the consensus of opinion that each Section should have a paid Assistant Secretary on part or full time, and that this should be considered in connection with the Council of the Society making funds available annually for the expenses of the Sections. Each Section was asked to prepare a budget for this season's work, sending this to the New York office for the consideration of the Society Finance Committee in connection with the preparation of the Society budget.

With reference to the membership increase work, September and February were settled upon as the best months in which to inaugurate special intensive organized effort. This feature is coordinated in the provisions of the Sections Manual. Chairman Hinkley of the Membership Committee of the Society presided at the session devoted to membership increase matters. He was supported by the presence of all of the other members of the Committee. Plans were formulated for the activities beginning this month, the Sections being again requested to give all possible assistance.

It is the feeling of the Membership Committee that proper discrimination must be maintained in respect to quality of members in the membership increase work. There is no advantage in the addition of members who do not reasonably expect to take a permanent or relatively long interest in the work of the Society. Chairman Hinkley reiterated his view that there should be no over-selling in the work of the Committee and that only men of known good character and legitimately interested in the automotive engineering fields should be asked to take S. A. E. membership.

Regarding requirements as to references on application blanks, an outline of procedure was approved that it is felt will be satisfactory in the case of applications received with insufficient member-reference evidence as provided by the rules of the Society in the first instance. While applicants will not be required to give the names of five members when this is not feasible, sufficient evidence will be required in connection with all applications, as to integrity and professional qualification, before they are submitted to the grading committee and the Council. This procedure contemplates the maintenance of that relatively high standard of membership which the Committee believes is very desirable.

Discussion of Papers at the Summer Meeting

THE discussion of the papers presented at the recent Summer Meeting of the Society included written contributions submitted by members who were unable to be present and the remarks made at the meeting. In every case an effort has been made to have the authors of the several papers reply to the discussion, both oral and written, and these comments, where received, follow the discussions. For the convenience of the members, a brief abstract of each paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, in case it is desired to refer to the complete text and illustrations.

THE ENGINE-FUEL PROBLEM

BY JOSEPH E. POGUE

THE engine-fuel situation has changed almost over-night. Oil-consuming activities have taken on an accelerated expansion and the situation has shifted from excess supply to a position where demand is assuming the lead and is seeking a supply. A gasoline stringency, accompanied presumably by a marked rise in price, is a prospect to be anticipated. The production of gasoline is increasing more rapidly than the production of its raw material, crude petroleum. The available supply of the latter is very limited in view of the size of the demand. As a direct result of the situation, gasoline is changing in character and becoming progressively less volatile. The low thermal efficiency of the prevailing type of automotive apparatus contributes strongly to the demand for gasoline as engine fuel and has a bearing upon the quantity and the price of this specialized fuel. While this now tends to work to the disadvantage of the industry it may be turned to its advantage since it brings into the problem the matter of supporting resources such as benzol, alcohol, shale-oil distillates and mixed fuels. The production of these products can be counted upon as need arises for them and the engine should evolve in the direction of adaptation to the new fuels. Fuel is now to dictate to the engine, and "the engine should listen well to all that fuel has to say."

The author outlines three stages of activity to be provided for in meeting the problems in the situation, economic analysis, material research and coordination between industrial activities. For the last no ready-made examples are to be found and the means for handling these functions will have to be built up for the first time from a point of view covering the new problems, since science can offer no solution if its scope is restricted.

The work to be done should be regarded as an emergency measure. Something more than laboratories engaged merely in chemical, physical and mechanical research is needed. Research to be effective must be applied to critical and pivotal points. We need to catch at once the natural trend of things, to develop the engine where needed advances are not being made with sufficient celerity and to bring a discordant set of individual policies into harmony with the demands of the situation. [Printed in the July issue of THE JOURNAL]

THE DISCUSSION

FRED WEINBERG:—With a given fuel, whatever it may be, its delivery to the engine precedes its use therein. The fuel delivery, therefore, is an element worth our consideration. Putting fuel into the car tank does not necessarily mean the obtaining of this fuel both as to quality and to quantity at the nozzle of the carbureter. There are two factors affecting the latter. First, loss in the car tank due to evaporation and spilling and second, chemical and physical changes in the fuel due to the heat encountered during storage and delivery.

In investigating these losses and changes the first is found to be due to ordinary temperatures of the tank if in the rear and to increase if the location of the tank is under the shroud or under the seat, in other words, in closer proximity to the engine. This condition is accelerated by the continued shaking the fuel is subjected to in traversing the roads and is partly accompanied by losses by spilling through the vent. Even in stationary tanks the evaporation of the lighter hydrocarbons of the fuel is enormous. Just observe the fuel haze around large fuel storage tanks. To drive this point home, let me add that the loss due to this stationary storage amounts to many million barrels of our best hydrocarbons annually. The oil people have recognized this and the old open-vented storage tanks are rapidly disappearing and being replaced by the closed Farr fuel storage system. The advisability of using devices to eliminate this loss should be investigated by the Society in connection with the fuel problem.

Leaving the matter of fuel storage and turning to the delivery proper, no appreciable loss is encountered in the ordinary gravity system. There are losses, however, in the pressure as well as in the vacuum system. The wastes in the ordinary direct pressure system are too well known and have been the object of criticism too often to be mentioned again. However, in pressure and vacuum systems using a small intermediate tank to which the fuel is delivered and whence it is fed to the carbureter by gravity, this small tank is generally located under the hood and in close proximity to the engine and is, therefore subject to the heat radiated from the latter. This heat is greatest in the summer months when the car is chiefly in use. I have encountered even in Michigan temperatures in the tanks in the neighborhood of 168 deg. fahr. The tanks, therefore, in these systems under such conditions act like stills and our already poor fuel is being led through them in millions of cars, the lighter, most valuable constituents commonly alluded to as the "kick" of the fuel, being distilled off and lost in the atmosphere. In itself, the heating of the fuel is beneficial, if anything, and as a matter of fact is one of the steps toward solving the fuel problem, if we can avoid a loss of the better and lighter hydrocarbons.

F. E. CARDULLO:—It seems to me that our problem is very much more serious than Dr. Pogue has indicated. We could count confidently that in the next 3 yr., by strenuous efforts, we will be able to produce enough gasoline to meet our needs, at what we may call reasonable prices, although most of us kick about them. But after

that, if the automotive industry is to continue to increase, it is quite certain that gasoline supplies will decrease, not only relatively but absolutely, and that there is going to be a shutdown on the growth of our present type of industry and even on the development of our present type of civilization, because the automobile has become, in this country at least, so much an element of civilization, the motor truck and the tractor are coming and these various other things, that it is a very serious situation.

It seems to me that there are five lines of attack on this situation. The first one is this: We are seeking not only the development of a useful fuel in internal-combustion engines for automotive purposes but also the use of fuel oils which have a large volatile fraction for internal-combustion engines, for stationary and for marine purposes, where it is not necessary. I believe that the first step ought to be to forbid the use of crude oil, as such, containing considerable volatile fractions or of anything except the non-volatile fractions of such oils, for internal-combustion engines, for stationary or marine engine purposes or for burning under boilers for the generation of steam. It is an economic waste to take a volatile fuel that is rapidly disappearing, for which there are adequate substitutes of a different kind, and to use that fuel for a purpose for which it is not necessary.

The second step is an idea of my own, and it is rather radical, perhaps, to some of your minds. It is the use of an automatically controlled gas producer, using either crude oil or the viscous non-volatile fractions of the crude, to produce a permanent gas to be used in trucks and tractors. I do not think we can expect to use them in the automobile on account of the lack of convenience, but it is perfectly possible to develop such a producer, of light weight, of proper capacity and of suitable properties, so that we may get a much more economical engine than the kerosene-burning or the gasoline-burning engine, one which will have a greater flexibility, which will get rid of many of our troubles, at the risk, of course, of introducing the troubles that we may encounter with the producer, but which I think will be a practical solution of the difficulty and rule the truck and the tractor out of the game as competitors of the automobile for the use of these types of fuel.

The third step is the standard method of developing types of engine and of carbureter design which will be capable to employ heavier fractions than those which we now commonly use.

The fourth step is one which is also coming to the front, namely, the introduction of more economical types of machines, having the lower power or ability factor, as it has been called, with better means of control, with possibly more speed changes, with more flexible engines, and in general the ability to get along with a less number of miles per gallon.

Then finally, because no matter what we do to conserve the supply of fuel oil, it is eventually going to disappear, we must have some method of developing a synthetic fuel from other sources of fuel supply, which will be adequate and satisfactory as a substitute for gasoline or for crude oil. We need to attack the problem along all five of these lines simultaneously. Some of them involve legislation, some involve research and the development of certain types of apparatus, others a campaign of education, and finally there is involved the entire coordination of the fuel industry, not only the automotive industry and the petroleum industry but also the coal, the city gas and the power gas industries, to solve the problem properly.

T. J. LITLÉ:—Being directly concerned in research work on fuel, but more particularly in the utilization of fuel, I believe it is incumbent upon the engine designer to meet this problem by better design. I do not believe the refiners can very greatly increase the supply of engine fuel. They cannot by local legislation or restriction, give better fuel except at a very much higher price. What the engine designers must do, is to develop an engine manifolded so that it can burn a fuel which today would represent about half kerosene and half gasoline, the present-day fuel. That can be done. Mr. Horning has told us that he has obtained a marked increase in fuel economy by the proper manifolding of a truck engine. The same thing will have to be done with the passenger car engine.

On an engine which is widely known in this country the throttle-opening on the carbureter is only 12 deg. 30 min. at 50 m.p.h., on a concrete road; the throttle is opened very little. That is just a significant state of affairs. We are not forced to economy; we do not know what economy means in this country. The Europeans know something about it because they are forced to it by the high fuel prices. They use more gear changes than we do; they use smaller engines than we do. We will have to do those very things soon.

We buy a high-priced runabout, carrying two people, weighing something over 4000 lb. It seems ridiculous to think that we have 2000 lb. of vehicle weight per passenger. That is one thought that we must take into consideration. We are lugging around a lot of automobile and carrying a very small load. We can greatly increase the fuel supply relatively by a more judicious design of engine and vehicle.

Fuel oil is used in this country for many purposes other than automobiles. The gas companies employ it for enriching gas. Attempts are being made throughout the country to adopt the British thermal unit standard, instead of the power standard. A fuel oil is being used which can be converted by the cracking method into engine fuel. We will have to conserve all of our oil, but I believe that it is the duty of the engine designer to meet the situation by a more judicious use of proper manifolding.

Mr. Horning said that by increasing the temperature of the induction pipe, he was able to cut the consumption of fuel from 8 to 5 gal. over a 16-mile trip. We can do exactly the same thing with the passenger car engine, and we must do it, because on a multi-cylinder engine in a high-priced car we are diluting the oil in the crankcase as much as 40 per cent in a 200-mile run, as an analysis of the oil in the oil-pan shows. That condition must stop. We must bring the temperature of our charge, as it enters the block, up to a certain point. It seems to me that the Research Committee of the Society should give us a few lines of thought in this direction. What shall be the temperature of the charge as it enters the engine? It is usually too low at the present time. Also what shall be the block temperature? With kerosene I say the temperature of the charge as it enters the block should be 175 deg., and the water temperature in the block nearly 200 deg. We must give thought to these matters and thereby save a tremendous amount of fuel. It is possible to gain 3 or 4 m.p.h. by judicious manifolding of a passenger car engine.

If we have 6,000,000 vehicles on the road in America and we save 2 gal. of gasoline per day, there are 12,000,000 gal. of gasoline saved daily. I believe that it is up to the engine designer to do that.

J. A. ANGLADA:—The automotive industry has been compelled to take the steps that have been recommended

to a certain degree, the degree being determined by the financial consideration. I think it would be interesting to hear from Dr. Pogue as to the steps that the other users of fuel oil have been or will be compelled to take. We have observed the Western locomotives and also the ships burning fuel oil, belching forth great clouds of smoke. That seems to indicate inefficient combustion. It would be interesting for Dr. Pogue to tell us what steps have been or will be taken to remedy that evident waste of fuel.

DR. J. E. POGUE:—I think those steps will have to be taken by the automotive industry. As the situation now stands, 49 per cent of the bulk of crude oil which is refined is converted into fuel oil, and a large proportion of that fuel oil is burned under steam boilers for raising steam. It is so used because fuel oil is so cheap, 3, 4 or 5 cents per gal., that it can be used in competition with coal. The only thing which will prevent that economic waste, barring drastic legislation which cannot be expected, is a rise in price of fuel oil that will take it out of the realm of competition with coal. Just as soon as the automotive apparatus can burn fuel oil, it can economically capture twice as much fuel as it now gets under the name of gasoline. So that problem is entirely up to the automotive industry, in my opinion.

There is a second idea that I would like to try to make clear in a moment. I have talked with many automotive engineers and men in the automotive industry with regard to this fuel problem, and the consensus of opinion seems to be that if the oil people will only tell us what we are going to get in the way of fuel, then we can build engines to meet that. It seems to me, as I analyze the situation, that the oil people cannot tell us that because they do not know themselves. The situation is analogous to that of a gunner on a battleship who, on a moving base, is forced to shoot at a mark which is moving, and says, "I will be a good marksman if you will let me stop my ship and the enemy stops his, so that we can shoot at a fixed mark." The fuel situation is an exact analogy of that. We are forced, on a moving base, to shoot at a moving mark. The trigonometry necessary to make good marksmen of us has not been worked out. In my opinion, the step now needed is to bring scientific methods to bear on working out accurately the acceleration of the base and the acceleration of the moving mark, so that we can develop good marksmanship. In my opinion, we cannot get anywhere so long as we wait, expecting somebody to say what the fuel is going to be. Nobody knows; nobody can determine without bringing the proper technique to studying what it is going to be. Then I believe we can determine within a certain extent what this changing character of fuel is going to be; it is going to continue to change. We cannot expect, I believe, a fixed, static fuel at any time in the future. We are going to have a gradually changing fuel, or a fuel which we can force into fixed characteristics over given periods of time, but at the end of that period the fuel will change again. The real problem is the very complex one of adapting an evolving engine, or a series of evolving engines, to an evolving fuel. It is exceedingly complex and intangible, but I believe it can be solved if the problem is accorded the attention and the investigation and the technique that its magnitude deserves.

M. A. SMITH:—Dr. Pogue in his paper earlier in the year brought out some points that probably should be mentioned at this time. The value of the fuel is not appreciated, we are not taking full advantage of the value of the fuel at the present time and have not taken advantage of it in years past. We know that the automotive engine is doing its work properly in the airplane, in the truck, in the tractor and so forth, but we have not thought about the loss of power we are now having due to the manner of using the fuel.

Mr. Litlé brought out the point that the work by the Research Committee should be applied primarily to the method of handling the fuel in the engine, its use in the engine to get its full value. I know of a great many analyses of crankcase oils in which the fine oil in the lubricating material showed a high percentage of light gasoline. If the contention that the gasoline is so heavy that we cannot get results and therefore we get it in the crankcase were borne out, we would not find a great quantity of light gasoline in the crankcase. Therefore, the method of getting the fuel into and using it in the engine is not fully understood. The light gasoline is present in the crankcase solutions just as the heavier ends are.

The petroleum manufacturers are very anxious to give the best material they can for automotive use. We are not developing the engine as fast as we should. We say that 5 yr. ago we did not have trouble with the gasoline, but we did have troubles which we did not notice so much because we had many other troubles at the same time. If we make the manufacturers of gasoline give us only the cream from the top, the price will be controlled by the law of supply and demand. We will have a condition very like European conditions, having to change gears all the time and be very economical in driving. We will have to learn a new system of handling our cars, just as the Europeans had to do when they paid 50 cents and $1 for gasoline. Let us work on the engine that we have now to get the full value out of the gasoline that we have now, and let the Research Committee on the fuel and engine problem come along and give us the new fuels or the new engine developments. In the meantime we will have done the best we could. We cannot do it all at one time.

H. C. GIBSON:—Dr. Pogue's suggestions for the future are excellent as to the procedure of the committee. There is, however, one addition that might be made to the suggestions given thus far and that is the development of oil from shale. I believe that there is plenty of oil to be obtained from shale. It is going to cost a little more, perhaps, or, on the other hand, it may not cost more than the present gasoline or liquid fuel direct from the oil. In the early development of shale there will be much shale oil wasted unless the method whereby it is obtained is determined beforehand. Even today, with all the knowledge that we have, we get a gusher that throws a pool of oil many acres in extent, all of which is wasted.

We have talked of the future and all that should be done, but there is also much to be done at the present moment in the utilization of the fuels that are being burned in the engines which are in the 6,000,000 cars running on the roads today. I believe that it would be a very good thing if the Society's committee could by that coordination that has been suggested and is most essential, arrange for the providing of a fund which would be applicable to the development of the actual device that is going to turn our fuel into a gas which can be used without inordinate waste. There are a number of people going along the usual road of the inventor, without any money and without the facilities for cooperation with the brains of those who know more than the inventors know. They have made a certain amount of progress. One of the best proofs of this progress is the test made by the *New York Herald* in the run of twenty-one cars from New York City to Washington, D. C., and return, in which six of the cars were using straight kerosene and three a mixture of half kerosene and half gasoline. Those cars did wonders. I happened to be in charge of that run

and had the opportunity of looking into the engines after the run. They developed all the power that was expected, just as much as you get with gasoline carried through the ordinary carbureter. Most of them had the heated manifold; the heat was controlled on none of them.

I am going to suggest that in the vaporization of any of the light fuels that we are using we have to proceed slowly. The point that we must heat the fuel gradually has not been recognized sufficiently. Any attempt to heat it by hot spots is bad, advertising to the contrary. The method must be slow, but we do not know how slow. It should be the work of the committee, through such an appropriation as I talked about, to determine how slowly that fuel must be heated, and to determine the maximum temperature that must not be exceeded, because we must meet those two points, heat slowly and not overheat. The only way in which we cannot overheat, or avoid overheating, is to use something in the nature of a thermostat which will take care of the temperature and by-pass the application of the heat. Some people are trying to work that out with the inadequate means that I spoke of before. It could be done most rapidly and at a very slight expense because there is plenty of material of all characters available to be tested out, combined and made into a workable device. Then it would be up to some manufacturer to take hold quickly and put that device on the market.

This involves the forgetting of the atomization question altogether. A number of carbureter people are still worrying about atomization. We have that to the fullest degree that we will ever need it. It is the heat that we require. That thermostat arrangement will enable us to meet the conditions of a different class of fuel. For instance, the apparatus could be set to take care of a certain class of fuel.

H. L. HORNING:—I think we can give assurance that the petroleum and the automotive industries will, without going too far into the economics of the question, be able to state definitely the quality of fuel for 1 or 2 yr. in advance. That is a very practical thing. The one thing that they have told us is that they do not know how many cars we are going to produce, how many tractors, how many trucks, how many motor boats, or how many farm engines; and in turn the automotive industry has told them that machinery was set up, and was being set up by law, to give them that information. With that information in hand, and also improvement in the statistics-gathering ability of the petroleum industry, which has been a weak feature in the past, there is no doubt that we will be able to predict with reasonable accuracy the quality of fuel 3 yr. in advance. That is the first step, therefore, in answering the question which has perplexed all engineers.

We are not going to have a shortage of fuel in this generation. We are now on the very verge of adopting those corrective measures in design that will allow us to meet the problem as it presents itself. One of the things we must bear in mind is that we have a large number of cars out, and the fuel that is sold must be burned in those cars.

DR. H. C. DICKINSON:—There are several points which I believe ought to be borne in mind and emphasized continually. One is that the automotive industry, as it exists today, is built up on the basis of a certain specific type of automotive engine, developed mainly because at the time of its incipient development cheap fuel of a special grade was very plentiful. That has led to the development of this particular type of engine, which has had more brain matter, more energy, more money and more time put on it than almost any other development the world has ever known. No wonder, therefore, that this particular type of automotive engine has been developed to an extremely high point of perfection. Nevertheless, the economic conditions which brought about the incipient development of this type of engine have changed radically, and that has meant, as is always the case, that the type must change or be adapted to meet the changing conditions. We may reach a time, as is almost always the case under such circumstances, when a radical change in type will become desirable. I hope we have not reached that time yet and that we shall not for some time to come, but this Society, being the livest of all engineering societies, must not forget that it has to be live enough to meet a situation which may demand a very radical change in its whole economic system in the near future. I do not mean within the next 2 or 3 yr., but some time in the future.

We have discussed and thought a great deal of the problem of research, systematic research, economic, material and coordinative. We must not forget that no type of systematic research is ever going to bring fruit in industrial success until it is put to utilization. Whatever may be looked for from a research committee that is organized to undertake the study of certain definite problems systematically, will eventually bring forth real fruit only as those solutions of the problem that are brought out in their skeleton form, so to speak, by the research committee or by the men who are working on those problems, are brought home to the minds of all the engineers and put into industrial shape. It is only to that extent that they will amount to anything in the revolution or revision of our industrial system.

The problem is presented to us in several different forms. There are a large number of partial solutions of the problem of a shortage, or possible shortage or reduction in our supply of fuel. The most immediate problem which presents itself is that of the best utilization of the present supply of the present grades of fuel in the present existing equipment. Somewhere between 5,000,000 and 6,000,000 cars are running and a large part of these passenger cars will be running for at least 5 yr. In addition to that we have many other appliances which are using gasoline. Probably a third of all the gasoline consumed is used for passenger cars. Therefore, the most immediate problem appears to be to see how we can conserve the present supply of present gasoline by the best utilization. It is a very unfortunate and unpleasant thought, and one which, no matter how much emphasis is laid on it, never meets with great enthusiasm, that certainly from 25 to 30 per cent of the gasoline which is going into the intake manifold at the present time is not doing any useful work. Some of it appears in the crankcase. The percentage that appears there is very small compared with the nuisance that it causes. The percentage that goes out in the exhaust is extremely large compared with that, and if we had some means of properly burning our present gasoline in our present engines, under existing conditions, with no increases in efficiency anywhere else, we could effectively supply 1,000,000 to 2,000,000 cars more than exist at present, without increasing our gasoline at all. That is one problem which is up to the engineers.

From a research point of view this broader problem involves a number of incidental points or problems on which we have not sufficient information to make the most successful solution of the whole problem. Among
ment of this particular type of engine, which has had

worry about carbonization up to about 5 yr. ago. The increase in the difficulties of carbonization have come with the increasing in the different grades of the gravity of fuels and the introduction of a considerable amount of cracked product. It would be very useful if we knew more about the carbonization.

Another problem which is perhaps more troublesome is this: We never used to have much trouble when climbing a hill at low speed, in getting fairly good performance, but as the gasoline has contained more and more of the heavy ends, we have more and more trouble with engines, especially at high compression, giving preignition. There is a question on which we ought to have some definite knowledge, and the compression ratio at which it is possible to run with various grades of fuel without difficulty of preignition is one question which the research committee of the Society has laid out as a specific point on which information is to be obtained. We know that as the heavy-end content of the fuel increases, the compression ratio of satisfactory running is decreased, and we want to know the figures necessary to deal with that problem. Incidentally, there may be some other important points that arise in that connection.

Mr. Kettering has given us much valuable information on the fundamental causes of this sort of preignition. I do not know that the problem is entirely settled; I believe it is an open field for still more information. I hope Mr. Kettering will feel free to give us something further along that line.

I think it is important for us to know whether it will be ultimately advantageous for the industry to develop along the lines of the utilization of a fuel which will contain everything from casinghead gasoline to fuel oil in one engine, or it is more desirable economically to develop two types of equipment, one of which shall have the advantages of our present volatile, convenient fuel, and the other of which shall sacrifice those advantages for the sake of economy and utilize the heavier grades of fuel. If we could burn our kerosene and our lighter fuel-oil constituents in trucks, tractors, motor boats, and so forth, now or within the next year, we would have the problem of the passenger car fairly well solved for some time to come. Whether that is good economic policy will depend upon the results of a research involving the study of the economic situation and also of the technical situation as regards the advantages and disadvantages of the two types of development.

STEEL TRUCK WHEELS

BY P. W. KLINGER

IN the past the majority of trucks have been equipped with wood wheels. These gave good service, but the results demanded under strenuous modern conditions seem, the author states, to make the substitution of steel wheels on medium and heavy duty trucks imperative. Truck engineers and builders seem to recognize the fact, but to hesitate to make the change, chiefly because a metal wheel is somewhat higher in first cost and because some designs have not as yet rendered the service expected of them. The service return of metal wheels is given from the records and reports of the London General Omnibus Co. and the Fifth Avenue Coach Co., both of which use steel wheels exclusively. The added mileage is greatly in excess of wood-wheel service and exceptional tire mileage is shown.

The author states briefly the arguments for the hollow-spoke, hollow-rim, the hollow full-flaring spoke and the integral-hub metal wheels. Semi-flaring or broad sweeping curve attachment of the spoke to the rim is advocated. The trouble with crystalline formation at angles and its remedy and other manufacturing problems are mentioned.

Two tables give information on the weights of four types of metal wheel, the results of strength tests of metal wheels and the strength of wood and metal wheels. [Printed in the August issue of THE JOURNAL]

THE DISCUSSION

F. A. MOFFITT:—Considerable trouble has been experienced in applying tires on metal wheels. It is stated that the tires change shape more or less. It is certainly true that they do not hold or maintain their shape. I would like to know what the members' experience has been with that?

RUSSELL HOOPES:—I want to make a statement regarding failures of wood wheels. We have been making truck wheels ever since the truck started, and our percentage of failures has been almost negligible, so that I can hardly bear out Mr. Klinger's statements that the wood wheels do not give good service.

CHAIRMAN B. B. BACHMAN:—The controversy between wood and metal wheels is one which will be decided absolutely on merit. I know that no metal-wheel manufacturer of reputation ever intends to convey the idea that the wood wheels are entirely bad, and I believe the same thing is true on the other side. On the other hand, the wood-wheel manufacturer undoubtedly recognizes that he has certain difficulties and problems to face in the future, and that he must maintain the standard of performance and of quality in his product. I believe that Mr. Klinger's paper indicates that the steel-wheel people realize that in the development of their industry it is not simply necessary to make a hole in some sand, pour something into it and get a good wheel out of it. There are some real engineering problems involved.

P. W. KLINGER: I will first take up the question of distortion in tire mounting, assuming that the so-called distortion of the bearing bore by the pressing on of the tire is referred to. I would say that there is a distortion, but one must go into the laboratory to find it. On a 40 by 6-in. wheel, with tires mounted under 65 tons pressure, there was an actual compression of the bearing bore of from 0.0003 to 0.0005 in. I believe it will be conceded readily that if we can hold our manufacturing limits to that, we will be happy. There are some things which merely require practice to demonstrate them, and I think it has been pretty well demonstrated in the use of steel wheels in the past year that the question of distortion is to say the least one of the smaller problems.

As to the wood wheels, I believe I stated that they are good wheels. I think the wood wheel has its place and so has the metal wheel. The increasing demands of truck service, as I attempted to point out, I think will require much better service from both the metal and the wood wheel than they have ever rendered in the past. I want to emphasize, particularly, the necessity of cooperation between the engineer and the foundryman. In the past the average foundryman has had to get quick results by common-sense methods. A good many foundrymen have been much averse to approaching engineering problems, but the possibilities of engineering as applied to foundry work have been brought out so forcefully by

war conditions that almost every foundryman in this country is now welcoming the assistance of engineers. There are some things in metal design which should be looked into very carefully. I want to emphasize again the necessity, before laying down the final, finished design of anything in cast steel, of calling in some foundryman who has had reasonably satisfactory results and consulting him before proceeding to manufacture.

THE PASSENGER CAR OF THE FUTURE

A SYMPOSIUM on the subject of the passenger car of the future was a feature of the Summer Meeting of the Society. Like the one on the Probable Effect of Aeronautic Experience on Automobile Practice at the 1919 Annual Meeting, several papers based on various points of view were presented. As all of the papers are more or less closely related and the discussion in many cases covers at least two of the series, it has been thought best to print abstracts of all the papers, followed by the discussion.

THE FUTURE PASSENGER CAR

BY E. H. BELDEN

EFFICIENCY, appearance and comfort will be the catchwords of the car of the future. Extreme simplicity of chassis will be needed to reduce weight and permit the use of substantial sheet-metal fenders, mudguards and bodies. The center of gravity should be as low as possible consistent with good appearance. For comfort the width and angle of seats will be studied more carefully and the doors will be wider.

A new type of spring suspension is coming to the fore, known as the three-point cantilever. Cars adopting it will have a certain wheelbase and a longer spring base. A car equipped with this new mechanism has been driven at 60 m.p.h. in safety and comfort without the use of shock absorbers or snubbers. It is the opinion of the author that this new spring suspension will revolutionize passenger car construction.

The author sees a strong tendency toward the sleeve-valve four-cylinder engine, stating that this type improves with use and compares favorably with the six-cylinder poppet-valve engine as regards vibration. There can be no great future for the eight-cylinder engine because of cross-vibration, or for the twelve-cylinder on account of weight, cost and inefficiency.

It is suggested that the time has come for Government inspection of the materials used in car construction and their treatment. A car designed to weigh 1800 lb. should not be allowed to travel above a certain speed unless proper materials properly heat treated have been used in its construction. Manufacturers should strengthen their metallurgical and inspection departments. [Printed in the August issue of THE JOURNAL]

THE FUTURE PASSENGER CAR

BY HENRY M. CRANE

PROGRESS toward a single standard type of car is not being made. Many different styles will continue to be needed to satisfy requirements of taste, ability, power and speed. Open cars, the backbone of production in the early days, are less in demand. Enclosed cars are already to be had in practically every grade.

While there is a trend toward lighter weight the demand for increased luxury and greater safety makes it seemingly impossible to reduce weight in either equipment or body. Just what the result of this conflict of ideas is to be is not easy to predict.

The author foresees considerable improvement in design and workmanship, a gain in economy of fuel, greater use of oil in lubricating chassis parts besides the engine, increased durability, and fewer objectionable noises. [Printed in the July issue of THE JOURNAL]

WHAT MOTOR CARS COULD BE

BY WILLIAM B. STOUT

IN attempting to forecast the future motor car the engineer is at a disadvantage; so many things might be done with car design which will probably not be done for other than purely engineering reasons. The motor car in its present form has probably reached a maximum of performance. If a radical economy is to be obtained radical but balanced ideas will be followed. The car at its best is still crude.

The firms which have always been leaders in the industry are already engaged in research along lines suggested by war experiences and fuel problems. The greater part of what has been learned has come through airplane development. For the first time what wood is and how to use it is known.

A 900-lb. five-passenger car would mean a revision of the fundamentals of some ideas on suspension; unsprung weight would have to be studied again and many ideas on axles and drive revised. The car would need a good 15-hp. engine, with other parts in proportion. Many small cylinders, not fewer than six, would be used. There should be a movement toward air-cooling, as it is now possible to build air-cooled engines with a mean effective pressure as high as that of the best motor-car engines and cool them under motor-car conditions. [Printed in the June issue of THE JOURNAL]

THE PASSENGER CAR OF THE FUTURE

BY HERBERT C. SNOW

THE limit of acceleration has been reached. What may well be considered a maximum for practical service has been secured. The present seven-passenger body is as roomy as could be desired. There should be no need for further increase in size. The author believes the total weight of this large car will be reduced to from 3500 to 4000 lb. To make this reduction without sacrifice of durability greater use must be made of alloy steels and aluminum alloys.

The tendency in body design and style is toward smoother lines, fewer breaks and a more graceful contour. The number of closed cars is increasing. There will be a general simplification of detail throughout, better wiring, better lubrication, an increased use of oilless bushings and fewer grease-cups. Brakes and wearing parts will be made more accessible and easier of adjustment. The take-up points for the various adjustments will be placed so that they can be reached with ease.

In the design of the engine the greatest improvement is to be looked for in cylinders, valve ports, valve mechanisms, manifolds and carbureters. More heat must be applied to the manifolds. Resistances in manifolds, valve ports and cylinders must be kept as low as possible. The six-cylinder engine will be used for the heavier cars, those of 3500 to 4000 lb., and four-speed transmissions. To provide a quiet drive for top speed the silent chain will be used. For the smaller sizes of car four-cylinder engines and three-speed

transmissions will suffice. By using a transmission with direct drive on the third speed and a geared-up drive on the fourth, it will be possible to retain low axle ratio and good low-speed performance, and at the same time have the maximum car speed available on the fourth gear. The construction of the transmission as a unit with the engine promises to become popular.

TORQUE RECOIL AND CAR WEIGHT

BY L. H. POMEROY

FEW points have aroused such discussion among users and engineers as that of the desirable number of cylinders in an engine. A large part of the work of the author has been in the direction of attaining the same ends as those achieved by the multi-cylinder engine but by different means. He discusses the relations between torque at clutch and number of cylinders and multi-cylinder engines and uniform torque, the factors governing torque recoil, torque recoil as a function of car weight and engine balance.

His conclusion is that the multi-cylinder engine now so widely used exceeds the real requirements and obtains its smoothness of operation at the expense of more desirable qualities.

A reduction in car weight would in his opinion, enable existing standards of performance to be maintained and even improved by the use of four cylinders for the heavier type, with all that this means in tremendous advantages to the automotive industry and to the user. In the near future the chassis will probably be designed to conform to the body work of the car, and there will be two types of chassis, one suitable for heavy closed and open bodies, and the other for bodies of the roadster type.

THE DISCUSSION

J. G. VINCENT:—I think those of us who are looking ahead are all doing research work without direct relation to anything we have seriously in mind in marketing in the near future. It is obvious that this must be the case if the industry is to go ahead. It is possible that everything mentioned in these papers may come to pass, but when the development comes it will probably be in clothing much different from what we know today.

I believe that this country is not going to turn entirely to economizing. Economy was talked strenuously during the war, and no doubt, due to war influence, will continue to be practiced but those who can afford cars of high ability will continue to buy them. I certainly think there will be a market for the comparatively high-priced car, of the greatest possible ability.

Analyzing the car of the immediate future, which is what I prefer to do, there are three general classes: the light-weight or small car, the medium-weight or medium-size car, and the large car. Of course there is bound to be overlapping.

As to what the engines of these various cars are going to be, I agree with Mr. Crane that no single type will predominate. I think that the four-cylinder engine will be very largely, but not exclusively, used in the small car. The six-cylinder engine will be the leader probably in the medium-size car, but it will at least have to divide honors with the four and the eight cylinder types. In the large car I think there is no chance for anything except six and twelve cylinder engines, although a new development may or may not have an influence, that is, an engine with the eight cylinders in line, which can be built without being excessively long and is in balance.

Putting the necessary apparatus into a four-cylinder engine to balance it may make it as complicated as some of the multi-cylinder engines, and it may give just as much trouble. As a matter of fact, the latter has been highly developed, and it is going to be made better and simpler as time goes on.

The principal point I would like to touch on is the matter of using the lower grade fuels. I think that is much more important than redesigning our engines with various numbers of cylinders. We all know how much smoother a result we can secure with an engine when we have perfect carburetion. With the present grades of fuel, which will evidently get worse, we must provide means for handling the fuel quickly after starting a cold engine, and without seriously interfering with the mean effective pressure of the engine at high speeds after it has become warmed up. I confidently look forward to the solution of that problem within the coming year. In fact, I will predict that this will be the biggest step to be taken this year.

JOHN MCGEORGE:—The talk this morning has been very largely in connection with what is known as the high-priced high-class car. I am going to attempt to indicate the direction in which improvement will go, but I want to put a few questions to you, to set you thinking about some of these things.

Why is the front drive not used? Why are we pushing the buggy ahead of the horse, instead of hauling it behind the horse? I know there are difficulties in steering, but these can be eliminated, and I believe front drive would be conducive to lightness in the car. In the small light cars, why are we building the chassis completely independent of the body? We are taking all the strength necessary for the road shocks in the chassis itself. There is considerable strength in the body; why not take advantage of it and build a combined chassis and body? Of course, you will bear in mind that I am speaking of the light cheap car, the production car.

In springing, why are we confining ourselves entirely to flat-leaf springs? Helical springs are much cheaper and lighter, and they have been successful in a great many cases. Why are we not developing that side of the spring question? Why are we not developing air springs, leaving out the steel entirely?

Why can we not employ a lighter material for bodies, this wonderful material we have been hearing of, the veneer with the new glues?

Light weight, combined with good roads, means a still smaller engine. The smaller engine means an air-cooled engine. Light weight means less fuel; a chance to use cheaper fuel. I see nothing impossible or radical in the 900-lb. car to carry five passengers, and the sooner it is developed the better.

Speaking of the sport feature of the passenger car, I have noticed that in going through a city and naturally wanting to see what is going on, with a covered body we have to get down almost to the seat to see what the city is like. Why cannot there be development so that the sights can be seen without stooping to the floor?

GEORGE W. SMITH:—When we get a car designed we have to build it. We have to consider the men in the shop. There is a very definite limitation to the quality of work that can be had from the kind of men that we can get. On that account, if we want to build a quality car, we have to get quality workmen, and the only way we can get them is to train them. This runs into considerable expense. Therefore, to be a success, to be sold to the general mass of people, a car has to be simple.

Mr. Belden mentioned the advantage of sleeve over poppet-valve construction. Valve setting is one of the least of our difficulties. I never expect to hear quieter

engines that those which come through our factory. Sleeve-valve engines are liable to trouble the same as the others. One of my friends had to abandon his car in the country on account of a sleeve sticking and it being impossible to proceed farther. I have never been unable to bring my car home under its own power.

I do not know that we fully appreciate what the automobile of today is, because we are all so very close to it. I consider it a very fine piece of mechanism, comparatively speaking. Anyone familiar with the production of machine-tools knows that the workmanship of the automobile compares very favorably with them.

My impression is that, all things being equal, the heavier the car the better it rides. High horsepower is not necessary at high speed. It merely provides acceleration at a comparatively high rate of speed. In the car I drive the engine will probably not exceed 50 hp. on the test block and yet the car will run 65 m.p.h. at any time on a smooth road. It is somewhat slow in getting up to that speed. I think that 45 m.p.h. is probably the average that a man should get when he is touring. On the other hand, to be able to run practically hour after hour at that speed the car has to be able to do 55 or better.

With reference to the advocating of the four-cylinder engine, I would say that I have seen stock six-cylinder engines running at 80 r.p.m., producing about one-third of their full torque. I have never seen a four-cylinder engine produce anything like that proportion of full torque at less than 150 revolutions. There is no argument on this matter. A six-cylinder car has a material advantage over a four-cylinder in driving comfort, in traffic and in other conditions.

H. M. CRANE:—In designing a five-passenger car, I freely own up to the utilitarian idea of providing the most luxurious method of transportation over the common roads of the country as they exist today. I admit that the resulting car would not be the cheapest means of transporting the five passengers from point to point. I am self-confident enough to think that I could design a 900-lb. closed car that would carry five passengers, if they could be induced to use it, but after one cross-country trip of any length, they would, I am sure, prefer the train for any further travel, and they would save money by doing so.

Automobile design is a matter of lineal dimensions based on certain definite limitations. The first limitation is, of course, the size of the largest human being who is likely to ride. The second is the wheel track on the average American road. The second limitation may in the future be removed, but the first will be always with us. To provide comfortable space for five persons, and by that I mean space which will seem comfortable even after a 200-mile ride, requires a structure of very definite length, width and height. I have no hesitation in saying that such a structure cannot be built including chassis and powerplant of any materials that we know of today to weigh anything like 900 lb. Furthermore, no 15-hp. engine could be expected to give a good all-around performance with a structure of such overall dimensions, regardless of its weight.

Mr. Stout is hardly fair to some of us engineers in believing that the value of wood as a material of construction was only discovered during the war. My earliest experiences were with boats of all kinds, in the case of which wood was the only reliable material we ever found that would give a light result. Later on I had automobile bodies of wood construction, and I have no hesitancy in saying that they were better than any metal bodies I have ever seen. Wood construction, however, requires far more care in upkeep, due to the material itself and to the glue used in construction than is given by the ordinary owner. Such structures must be kept completely covered with paint or varnish to insure the keeping out of any moisture.

Mr. Snow's paper is a thoroughly well studied consideration of his subject. There are only two points upon which I care to comment. The first is the proposal regarding the use of a four-speed gearbox with indirect fourth speed. The first car I ever built, designed in 1906, had a gearbox arranged in this way, the reason being my entire lack of comprehension at that time of the high-speed possibilities of the gasoline engine. I then regarded speeds of from 1500 to 1600 r.p.m. as very high. It was plainly impossible, due to such mental limitation, to do anything else than we did, expecting to produce a car that would give the desired performance under ordinary conditions and still have a good maximum speed on the open road. The cars built at that time are still in use, but the fourth speed is practically never used. With the present possibilities of six-cylinder car engines, I can see no commercial reason for anything of the kind. There is no difficulty today in building cars that can negotiate 10 per cent grades easily with closed bodies and full passenger loads on high gear, and that have all the speed possibilities that any roads in this country will stand.

The second point in this paper is in regard to the probable increase in power per cubic inch of displacement. If an attempt is made to carry such development to the limit, we will, I am sure, not reach a desirable result. What we all should aim to get is a car that will give the best performance with a minimum weight. I think that the maximum speed on the level is an extremely unimportant part of the performance. High maximum horsepower per cubic inch means high maximum speed of revolution and up to date has always been obtained by seriously curtailing the torque at the lower speeds. The slow-speed performance is also made less satisfactory by the necessary use of large valves and inlet manifolds, while the engine itself is probably heavier than a larger engine of slower speed would be. I am convinced by experience that the difficulties of lubrication and ignition vary at least as the square of the speed, while in poppet-valve engines the satisfactory functioning of the valve gear also varies inversely as the square of the speed. In actual practice the high-speed engine in the hands of the owner rarely, if ever, when called on, develops the reputed power, which has only been obtained at the factory by sacrificing some very desirable elements of operation.

Mr. Pomeroy has brought out very clearly in his paper a question that has proved to be of immense importance in airplane engines, that is the vibration caused by uneven torque reaction. In our 300-hp. eight-cylinder engine having a bore of 140 and a stroke of 150 mm., excessive vibration could easily be caused by uncertain ignition or by bad carburetion. On the other hand, with proper ignition and carburetion, this engine operates with extreme smoothness, in spite of its very short connecting-rods and rather heavy reciprocating parts.

In motor-car practice we have found that with good ignition and carburetion the effect of torque reaction appears under certain conditions. It varies, of course, greatly with the number of cylinders and also with the mounting of the engine in the chassis. In four-cylinder engines especially we have always found certain speeds of synchronism evidently based on the number of reac-

tion impulses per minute, on the mass of the engine and of the car weight and probably also on the vehicle springs. We have never, on the other hand, found such points in six-cylinder engines, although they were probably present, but to a degree not readily noticeable. On a four-cylinder engine these points are fully as sharply defined as the torque vibration points in long crankshafts.

I practically agree with Mr. Pomeroy that it is easier to get slow turning speeds with four-cylinder engines than with six or more cylinders. On the other hand, there is not the slightest doubt that a properly designed six-cylinder car can and will give a better slow-speed performance than any four-cylinder car. I would also say that I consider that there is no necessity of more than six cylinders to give the maximum possible in this direction.

DAVID FERGUSSON:—The paper by Mr. Pomeroy is, I think, particularly timely, as I believe that all automobile manufacturers are now working diligently on models that they consider will be not only right up-to-date but sufficiently advanced in design to last without material change for some years to come. I have never observed any particular inconvenience from torque recoil and great car weight. The Pierce-Arrow Motor Car Co. makes, together with other models, perhaps the largest and heaviest car in this country. This seven-passenger car weighs, when ready for the road but without passengers, 5500 lb. This has a six-cylinder engine of 5-in. bore by 7-in. stroke. Our latest engine gives a brake horsepower of 102 at 1000 r.p.m. There is certainly no perceptible discomfort to the passengers due to this enormous torque, even when taking advantage of the greatest acceleration possible.

The greatest factor to my mind is freedom from vibration, and I have always thought that the inherent vibration of four-cylinder engines, due to the angularity of the connecting-rod, is incurable. If this can be eliminated in the manner stated by Mr. Pomeroy, I think there is a great future for four-cylinder engines for automobiles. I cannot just see, however, how the Lanchester anti-vibrator can overcome the actual shifting of the center of gravity of the moving parts due to the angularity of the connecting-rod. I assume the device mentioned is the same as is now being used by the Packard Motor Car Co. in its twelve-cylinder engines. I can appreciate how this can dampen out crankshaft periodic vibration, but I fail to see how it can go beyond this.

Personally, I cannot see the reasons for any other types of engine for automobiles than the four and the six cylinder. The eight-cylinder is not in any better balance than the four, and it is very harsh running at certain speeds, and the twelve-cylinder engine is not in any better balance than the six and is not in any way a sweeter running engine. The six-cylinder engine is in perfect mechanical balance, and there is absolutely no need of more than six cylinders in a passenger car that is not required to carry more than seven passengers.

It is generally recognized as a fact in the type of engine under discussion that the greatest efficiency is attained with the least number of cylinders. There is less loss of heat to the water-jackets, there are less friction losses, and carburetion is more efficient; so that wherever it is possible to use a four-cylinder engine and obtain the desired results, this should be done. Simplicity in design is certainly an asset, and the car with the least number of cylinders that will give the best all-around performance is certainly worth the most money to the purchaser.

A. C. STALEY:—I am presenting a synopsis of a letter from W. J. Parrish of St. Louis, who has been a large distributer of high-grade automobiles for a number of years and has recently given up his agencies, due in large part to increasing complications in service problems. He feels that the gasoline automobile with its numerous complications is open to improvement and turns to steam as a promising solution of the problem.

Steam gives an ideal performance as to control, flexibility, acceleration and ability to burn low-grade fuels. Previous designs, however, have had serious drawbacks which prevented their universal adoption, such as fire risk, short boiler life, water mileage and general complication of automatic controls requiring skilled knowledge to prevent unreliability of operation. The time required to steam up from cold and the labor connected therewith are decidedly objectionable. Mr. Parrish feels, however, that these defects are by no means insurmountable and that a small part of the brains and ability that have been applied to the development of the internal-combustion engine would not only solve the steam problem but produce an automobile possessing practically ideal characteristics.

In line with this he submits the following list of specifications for consideration:

(1) A working head of steam must be raised from cold in less than 1 min., the labor to accomplish this on the part of the operator being limited to the turning of the switch

(2) One fuel, kerosene, a fuel oil, is to be used not under pressure in tanks and not requiring vaporization to avoid fire hazard. This can be mechanically atomized in a cold state and ignited by electric spark-plug, eliminating the pilot light and its accompanying annoyances

(3) The boiler must be long-lived, free from incrustation and simple and steady in construction. The semi-flash design used on thousands of steam cars met these requirements admirably. The system of control used, however, was open to serious criticism and possibly led those uninformed to criticize the boiler as the result

(4) The control system is to consist of electric motor driving water and fuel pumps and a blower. The air is to be furnished in definite quantitive relation, controlled by a steam pressure switch on a steam gage. In case of water failure due to an empty tank or any other cause, an electric thermometer cuts the fuel off at any predetermined temperature. The system cuts in and out as the demand for steam varies, the time of operation being proportional to the demand for steam

(5) By arranging the boiler coils in the form of a hollow cone the interior becomes a combustion chamber admirably suited to conditions of automotive operation. The use of a refractory lining is eliminated and the fire is fully enclosed in a heat-absorbing media

(6) The engine is to be highly efficient, preferably forward and reversing, with cam-driven poppet valves, and direct-connected to the rear axle, thus eliminating the transmission, drive-shafts and joints, flywheel, etc. The unsprung weight can be kept low. Two double-acting cylinders will give a ride to satisfy the most critical

(7) An efficient condensing system composed of a radiator and an exhaust-driven turbo fan will furnish ample water mileage

(8) The electrical system consisting of motor, generator and storage battery is simple. By suitable compound windings overchanging of the battery when the motor is down is prevented

(9) Freezing is prevented for 24 hr. by locating

all parts in close proximity to the boiler and by the use of electric or kerosene lamps storage in a cold garage for longer periods is possible without draining. Alcohol can also be used with an efficient condensing system

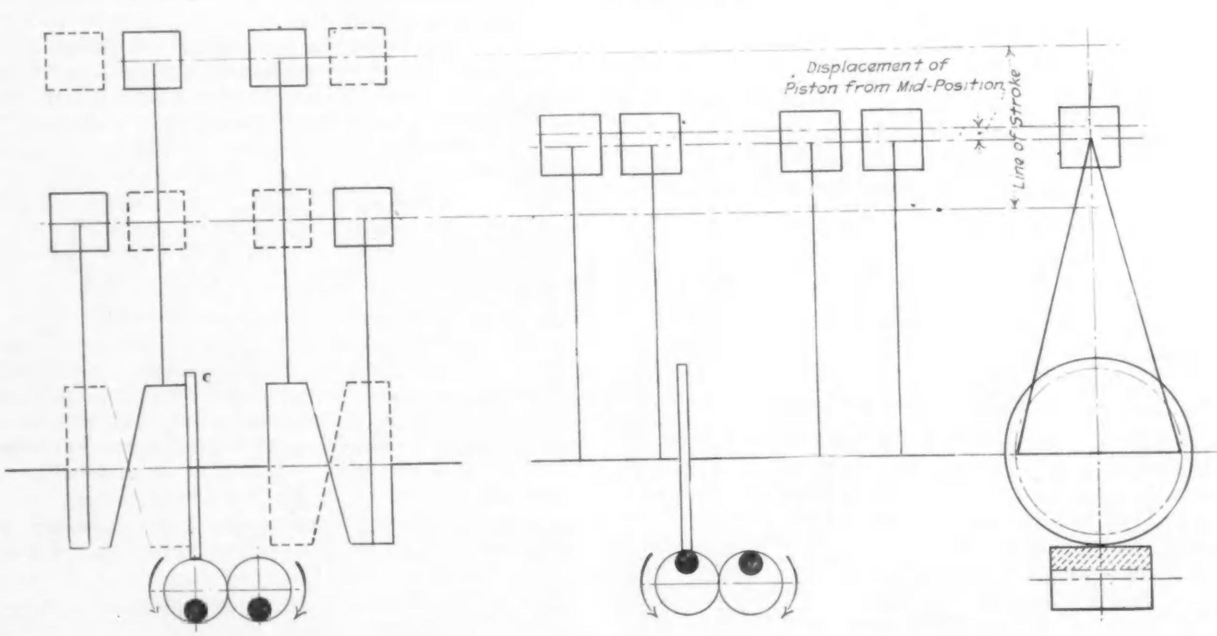
W. B. STOUT:—I disagree with some of the statements that have been made on the weight question. The lighter you build a car, the lighter in proportion you can make the unsprung weight. In other words, the lighter you make the car, the *easier* riding you can get. That will bear analysis. I believe that the more you think it over, the more you will agree with me.

The less the weight of the car itself, under you, the less it will throw you. With a car axle underneath you that weighs 500 lb. and you weigh, we will say, 100 lb., the axle has a five-to-one advantage. That is, when you go over a bump which lifts the rear axle off the ground, if that axle weighs more than you do, it is going to throw you through the spring. If it weighs less than you, it cannot throw you. If you can reduce that point where the weight is but a fraction of the weight above the springs, then you can go over a 6-in. curbstone and not be thrown out of the seat. That can be demonstrated. The light car can be made easier riding than the heavier one. If you will ask those who have come back from abroad where the roads were pitted with shell-holes and were driving there at high speed, they will tell you that a certain little car with a heavy ambulance body which gave the proper proportion of unsprung weight to sprung weight made the easiest riding on the front. That car was the Ford ambulance. Why? Because it has light, unsprung weight. I do not hold any brief for Ford cars, but I do hold that the best car is the one of light-weight construction. I believe this light car which has been mentioned can be made sturdier, of longer life, of easier riding, and at a fraction of the expense or cost per mile of previous cars.

C. H. FOSTER:—The breakage of springs on the Ford ambulances in Europe was tremendous. It was impossible to furnish springs fast enough to make repairs. Our Government placed orders for a large number of devices to stop the spring breakage and to make the ambulances ride better.

L. H. POMEROY:—In reply to Mr. Crane I quite agree as to the necessity for good carburetion and ignition to insure the smooth running of an automobile engine. An addition to the number of cylinders certainly does not increase the ease with which these desirable qualities are obtained. I am inclined to think that certain speeds of synchronism to which Mr. Crane refers are due to secondary unbalanced forces rather than to torque reaction. It would be interesting to learn the actual engine speed at which he found a periodic effect. If this speed is above 1000 r.p.m., it is practically certain that the effect is caused by lack of secondary balance. As regards the last part of his contribution everything depends, in my view, upon the size of the car. I quite agree that for a big car a six-cylinder engine will give a better slow-speed performance than a four-cylinder of the same size and with the same gear ratio, but it is equally certain that there are other conditions under which a four-cylinder engine can give better results than a six. It is necessary to get away from the broad terms of four-cylinder and six-cylinder and to consider the engine not as one of so many cylinders only but as part of a combination in which gear ratio and car weight are equally fundamental factors in determining performance.

In reply to Mr. Fergusson, the Lanchester anti-vibrator is a device consisting of two rotating masses *a* and *b* which are in effect bob weights geared together and rotated at twice the engine speed by the spiral wheel *c*. In this manner the secondary unbalanced forces which have a periodicity equal to twice the speed of crankshaft rotation are completely balanced out at all points in the stroke. The difference between a four-cylinder engine with the device and without it is astounding, and the lack of difference between a four-cylinder engine with the device and a six cylinder engine of the same size and running at the same speed is equally astounding. The Lanchester anti-vibrator, being a device in which the energy content at any particular engine speed is constant, absorbs no power in being driven other than that neces-



THE LANCHESTER ANTI-VIBRATOR, SHOWING THE POSITIONS ASSUMED BY THE ROTATING BOB WEIGHTS *a* AND *b* AS THE CRANK MOVES TO NEUTRALIZE THE SECONDARY INERTIA FORCES

sary to overcome the friction of the bob weight spindles in their bearings. The accompanying sketch will indicate the manner in which the anti-vibrator fulfills its express purpose, namely, that of neutralizing the shifting of the center of gravity of the moving parts due to the angularity of the connecting-rod. The bob weights are in the position shown at the left at the end of each stroke, while, when the crank is at 90 deg. from the dead center, the weights are in the position shown at the right. I quite agree with Mr. Fergusson's remarks as to the eight and twelve cylinder engines and appreciate his exposition of the essential virtues of the four-cylinder engine.

I yield to no one in my appreciation of the somewhat peculiar class of engineering called for in automobile work to satisfy what is sometimes a legitimate demand of the public, but more often one created by clever but fallacious advertising. Mr. Vincent states that four-cylinder, six-cylinder, eight-cylinder and twelve-cylinder engines each have their appropriate place according to the size or weight of the car in which they are used, which is precisely the point made in my paper; so that I take it we are agreed. I strongly disagree with Mr. Vincent's remark that putting the necessary apparatus in a four-cylinder engine to balance it may make it as complicated as some of the multi-cylinder engines which are now employed in passenger cars.

THE RELATION OF MOTOR-TRUCK ABILITY TO TREND OF DESIGN

BY LEWIS P. KALB

THE paper treats the subject of ability from the point of view of its relation to the present trend in motor-truck design, setting forth some of the fundamental considerations involved. An ability formula when applied to automotive vehicles is to determine a "factor of experience" from which engine sizes and gear ratios can be calculated. While passenger car performance is measured in terms of speed and acceleration, the latter are not the most important considerations in motor trucks, the speed of which is limited by the use of a governor. Wind resistance also is negligible at truck speeds. Practically the only resistances to be overcome by a motor truck are road friction and the force of gravity.

Both road and grade resistance are in direct proportion to weight carried and are usually expressed in terms of pound per pound. If the tractive force of the driving-wheels be expressed in the same terms, it becomes a simple matter to compare the resistance to be overcome with the force available for doing it. It makes no difference in truck ability what the location of the driving-wheels and the disposition of the load may be. The author uses eight formulas in developing his thesis and compares his equations with those of H. K. Thomas, C. T. Myers and Mr. Roebuck.

The problem of speed versus economy of operation is fully discussed. High speed costs money. Excessive high-gear ability costs money. As the fuel problem becomes more serious something must be done to improve truck economy and to enable truck engines to operate on the poorer grades of fuel. Marine engines use kerosene satisfactorily, something that has never been done successfully by either trucks or passenger cars.

The author believes that the use of pneumatic tires for motor trucks will greatly widen the field, but emphasizes the fact that high-speed pneumatic-tire trucks and slow-speed solid-tire trucks are two fundamentally different propositions and should be treated as such. He states that to operate successfully on pneumatic tires a truck should be specially designed for this service and have the characteristics of a large passenger chassis. [Printed in the July issue of THE JOURNAL]

THE DISCUSSION

JOHN YOUNGER:—The paper is a distinct contribution to the published data on motor trucks. The value of the paper lies not so much in the interpretation of the formulas, as in the use of them in conjunction with the trend of design to show what the truck of the future will be expected to do. The question really resolves itself into this: What are we going to do with our motor trucks and where are we going to run them? If, as Mr. Kalb points out, they are to be run under better and still better road conditions, there is no question that the high-gear ability will have to come down, still retaining an emergency low-gear ability to meet the "off-road" conditions. There is further the question of climatic conditions to be considered. Trucks are now being used winter and summer, and our winter road conditions are so totally different from those of summer that the former should be studied carefully to insure the truck not suffering from a lack of power under heavy conditions.

These remarks will show that certainly a four-speed transmission is necessary and that we might even come to a five-speed transmission, though the commercial disadvantage of this last will probably prevent its full adoption. It is my opinion that in the four-speed transmission, the third speed or the second highest speed should be close enough to the high speed so that the latter can be used to a considerable extent under winter conditions or when the roads are not just up to par. The gear ratio should certainly be down low, and it would seem that ratios as low as 6 to 1 would be desirable, particularly for heavy trucks.

Mr. Kalb's remarks concerning the trend toward the use of pneumatic tires on trucks are interesting, but I am inclined to think that his conclusions regarding weight are not quite correct. The present truck engine, transmission and torque transmission members are very much heavier per cubic inch of piston displacement than the corresponding members of the passenger vehicles. One has only to examine the small transmissions used in modern passenger cars, equipped with engines giving for example 36 hp. at 1000 r. p. m., and compare them with transmissions used with $4\frac{1}{2}$ by 6-in. truck engines to realize the long distance the truck engineer has to go in the way of saving weight. This condition has been brought about largely by the use of solid tires, and I believe that when pneumatic tires get more into use on trucks (as they undoubtedly will) they will bring about a complete revolution in truck engineering. As a rough estimate, so that this matter can be visualized, I would almost go so far as to state that the 4-ton truck of the future running on pneumatic tires will have structural or load-carrying members practically the same as those of the 2-ton truck today, and that the powerplant and the power-transmitting members will have the same capacity as those a 4 or 5 ton truck has today, but at the same weight as obtains on the present-day 2-ton truck. In other words, the total gross weight of the 4-ton pneumatic-tire truck will be to all intents and purposes the same as that of the 2-ton truck today.

I suggest in connection with this trend that the aban-

donment of the governor be considered. The great use for a truck running on pneumatic tires will be in interurban traffic and there road limitations will be sufficient in the governing of the speed of the truck.

Mr. Kalb states that no one knows whether road resistance is more or less with pneumatic than with solid tires. Those of us who have had the opportunity of riding hundreds of miles in trucks equipped with pneumatic tires, as well as in trucks equipped with solid tires, can point out that on average give-and-take roads the road resistance is certainly much less in the case of pneumatic than of solid tires.

H. L. HORNING:—I take great pleasure in referring to a test over a standard course, which we have been making recently, that illustrates the point which Mr. Kalb has brought out so well, that with the proper gear ratio or ability factor in a truck, the problem of fuel disappears. In this particular test we loaded a 5-ton truck with 8 tons, so that we would get the conditions which usually obtain in service. We also speeded the truck up to 18 m.p.h., likewise to duplicate service conditions. We ran the truck over this course of 16.8 miles, which was as typical as we could get, as in it there were fine macadam roads, ordinary dirt roads, slight inclines, one ½-mile hill, grades running up to 9 per cent and some 2 miles of crushed stone. We went over the course on 8 gal. of so-called gasoline.

Before the next trip we made some carbureter adjustments and brought the gasoline consumption down to 7 gal. Believing that there might be some working factors on the truck that disturbed the conditions, we took off the vacuum feed, and, while I do not want this taken as a final answer, we found that the vacuum feed accounted for 2 gal. in the 16.8 miles; that is, we were burning 2 gal. more due to the vacuum feed. Now that need not be a condemnation of the vacuum feed, but it certainly indicates a possible source of fuel consumption and should suggest some very serious investigation along this line.

We then put on a combination manifold in which the charge was heated up considerably. Theoretically, from the standpoint of an engine tester, we reduced the volumetric efficiency enormously, so that on a brake test the horsepower would, no doubt, have been reduced 25 per cent. Strange to say, on the road the power actually appeared to be more. In other words. we had a better utilization job, a better job practically on the road. We next brought the gasoline consumption down to 5½ gal. Then we made some other very careful tests and brought our gasoline tank, which was about 7 ft. in the air and gave considerable head on the gasoline, down to a level, and we got down to 5⅛ gal. Then, by very close adjustment, we got down to 5 1/16 gal. This was the best performance we had with that line of action. In the meantime we had reduced the compression of the engine considerably, so that it would not knock on the hills, which is a familiar thing to all of us. Then we put in some kerosene and made the trip with the combination manifold on 5 3/16 gal., or only 1 pt. more than a fair gasoline performance. We thought that was a good result. It could not have been attained except by the special manifolding and by adding load to the engine. We calibrated the governor valve, so that by looking at it we could tell what load was on the engine, knowing approximately the speed, so that as we were going along we could tell about the load.

When we burned kerosene there was only the slightest difference on some grades. There was no grade on which there was a marked difference of the gears that we had to go to. After reducing the compression to 60 lb., we took the trip on kerosene without having a pound in the engine. This shows what can be done by proper gear ratios, proper manifolding, etc., in meeting the fuel problem.

I want to speak of one other thing. As you decrease the ability factor on high speeds, you in very many cases reduce the ton-miles per day. There is an inference which you can draw very quickly from the formula, that if you arrange to have a high gear, you will make more ton-miles per day. That is not so. We have had numerous instances in which with a lower gear ratio on high gear there were more ton-miles per day on a given route; that is, under conditions where there are miles of road on which, if the truck ability were not just right, we would have to go back to third speed, if we had a four-speed transmission. Therefore I want to call attention to the possible mistake we may make in getting too high or too low an ability factor. Every condition calls for a definite thing.

J. E. HALE:—I would like to bring out some points in connection with Mr. Kalb's remarks on pneumatic tire truck equipment, to give some idea of what we believe is going to be the trend and what ought to be taken into consideration by any designer. Many truck engineers here looked over our fleet of pneumatic-tired trucks. They have asked about the torsional stresses due to braking at high speeds and about the strength of various parts when we overload the trucks. Without exception, every one of them has said, "I do not see how you do it." It happens that we are not highly proficient in truck designing and that sort of thing; so we cannot answer all the questions. All we can say is that all these things go along very nicely.

It has been our practice to use more or less standard trucks, except that we generally put in a larger powerplant. On long hauls the trucks have in many cases to negotiate hills, and without a larger powerplant they would necessarily have to run more slowly. We have no trouble. I bring this out to emphasize that whatever you do in your calculations, it would be a good idea to investigate some actual performances to check up against when you have the pneumatic equipment.

We have five trucks running now with no differential in the rear axle. Some of them have been in service about a year, and at the present time we think things look very promising. Up to the present time we have not been able to establish the fact that there is any difference in the pneumatic tire wear with or without the differential. I give you the information for what it is worth.

JOSEPH HUSSON:—I would like to ask Mr. Hale whether he has any figures regarding the mileage of the pneumatic tires that have been running on the trucks between Akron and Boston; also, what chassis weight reduction they have made on the trucks. I was told a year ago that they were going to cut about 800 lb. off the chassis weight due to the fact that they had mounted pneumatic instead of solid tires.

MR. HALE:—The mileage figures we get on the tires running between Akron and Boston are not highly satisfactory for the reason that the trucks are run on a 24-hr. schedule. There are two drivers; one sleeps while the other is driving. They stop only for meals and gasoline. Consequently, the tires are very much abused. No locomotive is ever run anywhere near the distance that we run those trucks, 750 miles from Akron to Boston, right through without any stops. The methods in our organization permit the drivers to take some liberties. For instance, after they run 150 miles, supposing something happens, they run over a projection and the tread or the

side wall of the tire is badly cut, the drivers pay no attention to it; they go right through. Of course, after any accident of that kind the tires should be repaired. It is abuses like those which cut the mileage.

I can give information, however, which may be of interest. Running between Akron and Cleveland, we have no trouble in getting over 10,000 and 12,000 miles with the 10-in. tires, which are still in the developmental stage. Eight-inch tires in a similar run would give from 15,000 to 20,000 miles. That presupposes an opportunity to look the tires over and give them a fair chance.

Now on the other question, our problem has been to interest the truck designers in eliminating the chassis weight, and the thought of cutting out possibly 800 lb., as mentioned, was largely the result of discussing various phases of the situation with different truck engineers; that is, it became apparent that this might be possible. We have never been able to do very much in that way because we are not in the truck-making business; we have to depend on cooperation with the truck manufacturers. The most promising thing we have accomplished is to take a 2-ton truck, 2-ton in every respect except that it has a 3½-ton engine in it, and carry 3½-ton loads on it regularly. If I remember correctly, the truck has gone about 7000 miles with no apparent detriment to it.

JOHN MCGEORGE:—What is the condition of the road between Cleveland and Akron? Is it not good brick road?

MR. HALE:—It is paved all the way and there is very little poor paving. There is only a small percentage of hills on the road. On the Akron and Boston run the hills are very severe.

H. C. GIBSON:—I believe that all of us would be interested if Mr. Horning will explain the reason, if he has one, for the losses due to the use of the vacuum method of feeding fuel.

Mr. Horning, as usual, although he used an old gun, used one that hit the target pretty fairly. If I might put the explosion in the shell, it is that the bug of volumetric efficiency has not so big a sting as we seem to think it has. The bigger point is the utilization of the fuel. I feel that the Society should devote more attention to that grave question.

MR. HORNING:—In regard to the vacuum tank, we had a theory that, due to the floats going up and down and the sudden stopping, and so forth, it might surge full and overcharge itself on a vacuum when on the level. The higher vacuum on the level, where the demands on the engine are very little, may fill the tank full. There is a constant play in the vacuum tank to approximate the correct level. First it will fill and then it will go below, and then it will fill and go below. The same thing happens on the carbureters. We proved it on the tanks. When we had a high head, we found the carbureter filled way beyond the level it should have. That is one reason we always find that an engine works differently in a truck than when on a block, and it is one of the reasons we should give special attention to the needle. If you will take the little plug off and watch the needle rising and falling in the carbureter, you will note a phenomenon that we have little understood.

On the next question, we had some engine trouble in Texas and sent a man down there. It took 15 gal. to make a trip. Putting on a combination manifold, we made the same trip on 10 gal. We never failed to reduce the gasoline consumption 20 to 33 per cent. It is absolutely a utilization problem.

There is one interesting thing I want to call to your attention. On this trip the maximum speed was 16 m.p.h. The average speed was between 5½ and 8 m.p.h. That is a very significant fact; a factor that is practical. The average speed we obtained on the road, a practical, typical road, was 5½ to 8 m.p.h., whereas the truck was geared to go 16 miles. There is a basis on which we must figure. We cannot get good fuel consumption, if we take our theoretical figures. We must use the ability formulas advisedly. That particular truck had too high a gear, and yet it figured out beautifully 16 miles.

Another thing we proved was that we got better economy with than without a governor, the governor acting as a sort of safety device when the engine lost speed, at the time the engine was not needed. For instance, on a hill the governor shuts off quickly, and where you have a number of hills there is no doubt that there is a definite and very valuable saving due to governors, provided they act properly. Of course, the question is to get them to act properly.

C. T. MYERS:—This whole paper is one that is rather close to my heart, because I started back in 1911 to develop formulas of this kind and to interest people in using them, without anywhere near as much success as Mr. Kalb has had. Probably the reason for that is that his presentation has been a very able one.

Mr. Horning's warning to us that these formulas must be used advisedly is good advice. You also have to use a 2-ft. rule advisedly, either on the person of some very obstreperous child or for other good dimensional reasons. These formulas are nothing but 2-ft. rules. They are something against which to check and measure performance so that when we are all through making measurements, we can record them and have something to which to refer. The advisability of having such a thing is more than self-evident. The motor-truck manufacturers have tried practically everything. They have high ability and low ability and three and four speed gearboxes, and they are all trying to get certain results.

L. P. KALB:—Mr. Horning is entirely right that ability formulas should be used advisedly, but I think Mr. Myers gave the best answer to that which any one could possibly give. An ability formula is simply a means of measurement or of comparison, and we must take into consideration all such varying factors as mean effective pressure, efficiency and road resistance.

APPLICATION OF LIBERTY ENGINE MATERIALS TO THE AUTOMOTIVE INDUSTRY

BY HAROLD F. WOOD

THE author discusses the different types of material used in the production of the Liberty engine, the physical properties of the finished parts and the heat treatments used in making them, applying the information as set forth to the automobile, truck and tractor industries. Under their several heads the different engine parts are discussed with close attention to details. Chemical analyses are given for each part and approved heat-treating temperatures are indi-

cated. Quenching, direct and indirect, water and oil cooling, hard spots, warpage, scaling and hairline seams are treated. The advantages and disadvantages of the Izod impact test are stated briefly.

After discussing the various engine parts, the author makes definite recommendations for the use in detail of the materials discussed, with many hints, warnings, suggestions and comments along lines of practice and closes the paper with a statement that if the proper authority be given to the metallurgical engineer as to the handling of the steel from the time it is purchased until it is assembled into finished products, mild-analysis steels can be used and quality guaranteed. It was only through careful adherence to the fundamental principles outlined that it was possible to produce 20,000 Liberty engines without a failure of a single engine from defective material or heat treatment.

The Discussion

Dr. John A. Mathews:—I feel that this paper would have been of still greater interest if Mr. Wood had discussed more fully the troubles that were encountered in connection with the materials used in the Liberty engine program, for we can often learn from failures as well as from successes.

In reference to his principal conclusion as to the use of low-alloy steels, I feel that this is an admission of the limitations of the basic open-hearth process for the manufacture of higher alloy steels, at least by most makers of basic steel. The British makers of aircraft have been engaged in the business somewhat longer than we have and insist upon the use of a steel of the type X-3340 for their crankshafts, owing to serious troubles experienced with low-type chrome nickels, due to fatigue failures. The higher type of alloys well made will give better physical properties with less radical treatment, and if we are to progress in the aviation field toward lighter weight and more power, we must resort to the use of the very best steels that can be made. I feel that the advocacy of the type of steel shown in this paper is a step in the wrong direction, although one might admit that it is better to use low-alloy steels that can be reasonably well made in the basic open hearth than to attempt the use of high alloys improperly melted and fabricated, but when the higher alloys are well and properly made they are unquestionably superior for such exacting uses as are met in aviation engines. We have demonstrated very satisfactorily that these high-type steels can be manufactured almost altogether free from hairlines, while we have seen the low types of chrome-nickel steels exhibiting abundant hairline defects in the finished forging.

I think we will not be safe in assuming as yet that blue brittleness is a function of acid open-hearth steel. The best British alloy steels are made by the acid process, and if trouble was encountered with acid steel in the Liberty engine program, it is more reasonable to assume that it was due to poor melting or fabricating practice than to the fundamental limitations of the process itself. It is pretty generally conceded that acid steel is superior to basic in almost every way, and a further investigation will have to be carried on before we can assume that blue brittleness is a peculiarity of acid steel.

J. Heber Parker:—I personally know that Mr. Wood was to a large degree responsible for the metallurgical success of the Liberty engine and his detailed account of some of the troubles encountered, together with the means of overcoming them, should be helpful to those responsible for the metallurgical success of automobiles, tractors, trucks, etc.

He displays much commendable discretion in refusing to commit himself regarding the relative machineability of various types of alloy steel. Machineability is a quality or property that is almost impossible of definite determination on any standard basis. It is found that in different shops different machine tools are used, different feeds and speeds, different cutting angles on the tools themselves. There are so many variables that a steel which would be considered readily machineable in one shop would be thrown out in another. This matter of machineability has been discussed over and over again but with no definite conclusion, and in last analysis it must be left to each individual shop whether one alloy steel with a given Brinell hardness machines more or less easily with the practice current in that particular shop.

It is interesting to note that the crankshaft, the most highly stressed port of the Liberty engine, and one therefore which called for the highest grade of steel, was made from a nickel-chromium alloy. The author states that hairline seams occur generally in high nickel-chromium steels. Dr. John A. Mathews in discussing a paper on "sonims" at the recent meeting of the American Iron & Steel Institute showed that a high chrome-nickel steel for the manufacture of crankshafts for Rolls-Royce could be produced practically free from these hairline inperfections when made in small electric furnace heats where great care was taken, as compared with a rejection of practically all of the crankshafts made for Rolls-Royce from high chrome-nickel steel made in large open-hearth furnaces.

This experience of Dr. Matthews shows very conclusively that when those responsible for the metallurgical success of products of the automotive industry desire to secure alloy steel for highly stressed parts, a steel capable of developing high physical properties and causing little or no rejection in manufacture, it must necessarily be a quality product made in small electric furnace heats and handled by those with a long successful experience in the manufacture of alloy steels.

George W. Smith:—I may be much mistaken, but I fail to note any steels mentioned in the paper that are radically different from those we have been using for some time. I agree with the author on the desirability of using comparatively mild steels.

It is an economic crime for a manufacturer to add cost to a vehicle so extensively used as a motor car or truck, when it is entirely unnecessary. Occasionally it is necessary, when you run into trouble, owing to limitations of design, to substitute an extremely high grade of steel. The results are secured only by infinite pains in the hardening room, in inspection, in the laboratory, in every department of the factory; and the forge shop particularly is affected by the use of high quality steels. Overheating is a crying sin in the forge shop. With the higher steels the fault of overheating is considerably less. I know of a case where a part was made of a high quality steel and the results would have been infinitely better on the average if the lowest quality of steel possible for use in that place had been substituted.

F. E. Cardullo:—I note from the paper, that in accordance with usual practice, a case-hardened piston-pin was used in the Liberty engine. I happen to have been through a good deal of grief, with case-hardened piston-pins. From experience with two or three different airplane engines, I have found that steel 6145 (40 to 50 carbon chromium-vanadium steel), properly hardened and drawn to give a scleroscope hardness of about 65 makes a piston-pin that is as reliable as a case-hardened pin, besides being considerably stronger. Certainly you could not ask for more. Such material when cut from a prop-

erly heat-treated pin can be bent about a diameter equal to its own thickness without cracking. A pin of 65 hardness cannot be scratched by anything that you are likely to get into an engine, short of emery, and if you did get emery into the circulation system, it would certainly scratch a case-hardened pin. There is no question as far as the durability is concerned. I have never known of an engine equipped with material of this kind showing any trouble from the pins, but I have known of a good deal of trouble with improperly heat-treated case-hardened pins of the other type.

H. F. Wood:—In connection with the use of a case-hardened pin, as a metallurgist I believe in the elimination of every possible case-hardened part of an engine or any mechanism. In automobile work I strongly advocate the use of oil-treated piston-pins, and of all the materials recommended steel 6145 is my first choice.

The use of oil-treated piston-pins on the Liberty engine was not a success. We have tried this many times. The original specifications called for a carbonized piston-pin of steel 3115, which is a low chrome nickel, 10 to 20 carbon. Trouble was experienced with this pin, due to the narrow heat-treating range. The next material tried was steel 3345, which is a standard 3 per cent nickel, 70 to 90 chrome, 40 to 50 carbon, oil-treated. Due to the high explosive force of an aviation engine and the particular section of the pin, this material was not a success; approximately six engines failed on account of the use of it. Then chrome-vanadium steel, 47 to 52 carbon, which corresponds to the high side of steel 6145, was used, in hardness all the way from 60 to 75, and failures resulted. We found that with the use of a high nickel steel, with very low carbon, in getting the core heat treated to maximum toughness and the case heat treated to a reasonable hardness, never a failure could be obtained. Whether in the general automotive industry you should recommend the use of an oil-treated pin to take the place of the case-hardened pin depends entirely upon the design of the particular engine in question. For that reason, I advocate going very slowly in the adoption of oil-treated piston-pins.

Relative to Dr. Mathew's statement covering the use of low-alloy steels for highly stressed parts, it was not my intention to discuss in any manner the use of any particular method for the manufacture of steel. The conclusions expressed were drawn solely from the standpoint of a steel user and not of a steel producer. It is very well in this connection to state that the type of alloy steel selected for a particular part depends to a large extent upon the section of the part in question. It has been my experience on the aviation program that on all the sections up to and including 2-in. diameter, it is not necessary to use steel of a higher analysis than the steel specified for Liberty crankshafts, to secure excellent physical properties.

It is a well established fact among production manufacturers that a Brinell hardness of 321 is the limit to which a forging can be heat treated and still obtain any degree of production on machining. For that reason a well-made mild alloy steel when heat treated in sections up to 2-in. diameter will give as good physical properties as can be obtained with a steel from high-analysis alloy steel heat treated to the same Brinell hardness, with the exception that the reduction of area will be from 1 to 4 per cent lower.

A large number of tests have been made by one of our largest crankshaft manufacturers to determine exactly the effect of reduction of area on the fatigue resisting properties of material. By the Stanton test and the Fuller test it was found that the fatigue resisting properties were but little affected by the reduction of area, but were mainly a function of the elastic limit. It is my opinion that the use of higher-analysis alloy steel for light-section work to secure high fatigue resisting properties is apt to be somewhat misleading.

I believe that the high-analysis alloy steel will give consistently better resistance on impact than lower analysis steels. Inasmuch as from a commercial standpoint the value of the impact test has not been established I put little weight on this condition.

I agree absolutely with Dr. Mathews that it is possible to make a high-analysis alloy steel that is practically free from hairline defects, but I wonder if from a commercial standpoint the average user of alloy steel can afford to pay the price necessary to secure the steel free from a defect, the effect of which has not been established as to lowering the service properties of the material in question.

In regard to the properties of blue brittleness, there has not been sufficient information as yet to decide definitely whether this is a peculiarity of acid open-hearth steel. As stated in my paper, work is being done at the present time by the National Research Council to determine which types of steel this phenomenon applies to and to what extent.

I agree with Dr. Parker in that it is very hard to make definite statements regarding the relative machineability of various types of alloy steels. The statements made in the paper are taken from the opinions given at a large number of manufacturing plants where the different types mentioned are used. In regard to the selection of nickel-chromium steel for Liberty crankshafts, I desire to emphasize that it is not my wish to belittle the quality of nickel-chromium steels. There is no question that as a whole nickel-chromium alloys will meet as wide a range of physical requirements as any type of steel yet produced. It has, however, been my experience that when the cost of the finished part is taken into consideration in the case of many parts equal physical properties and service conditions can be met by using chrome-vanadium steel at a considerably lower cost.

With the conclusions of Dr. Parker that it is necessary for those responsible for the metallurgical success of highly stressed products to use a steel capable of developing high physical properties and a steel which will cause little, if any, rejections in manufacture, I agree absolutely, but in the selection of this material the question of section used must be taken into consideration as this will vitally affect the analysis specified, as the use of a too high analysis steel for a given set of physical properties on the lighter sections will only result in a large amount of rejections in the manufacture of the finished product.

Dr. Parker states that in his opinion this steel must necessarily be made in small electric furnace heats and handled by those with a long successful experience in the manufacture of alloy steels. It is an absolute fact that a steel used for any highly stressed mechanism should be produced by persons with as long successful experience as possible, but I do not believe that it is necessary that the product be made in small electric furnace heats. In view of the fact that only approximately 15 per cent of the material used in the Liberty program was so made and that the rejections of finished parts due to defective material was less than ½ per cent on all alloy steels used, I do not believe that Dr. Parker is justified in drawing this conclusion.

PROGRESS IN NAVAL AIRCRAFT

BY COMMANDER J. C. HUNSAKER

NAVAL aircraft are distinctively American types. Only one foreign seaplane was copied by the United States during the war, and when finally put into production it resembled the British prototype in externals only. While the Navy does a large part of its own designing and building through a corps of naval constructors, its theory of manufacture is to assemble parts procured from separate makers, and private design and construction are encouraged by contracting with builders. Available talent both in and out of the service and the facilities of parts makers, the new materials developed during the war and organized engineering which drove the entire process toward speedy results were appropriated by the Navy. The NC flying boat is typical of U. S. Navy practice. In the same way the dirigible C-5 is a purely American type.

The development of really large flying craft before 1917 was held back because no suitable engine had been designed. When the 350-hp. Rolls-Royce became available the four-engine Handley-Page plane was brought out in England, but no American engine was in sight until about August, 1917, when preliminary work on the Liberty began to look promising. One of the weapons needed to keep down the submarine was the flying boat. By 1918 America had a large program for these and the Navy was at work on the larger types for quantity production in 1919. The author sketches rapidly but with some detail the development of every part of the NC-4. The special equipment used in the Transatlantic flight is described. The paper is concluded with a description of the tests of the NC-3 at Rockaway. A number of curves are shown and a complete list of specification data is added. [Printed in the July issue of THE JOURNAL]

THE DISCUSSION

R. H. UPSON:—**I have a brief comparison, based on Commander Hunsaker's figures, with a hypothetical airship designed to lift approximately the same load and travel at the same speed as the NC-4 boat. Usually the airship or dirigible has been considered as a slow-speed craft, hardly comparable with the airplane in this respect, but having in turn certain qualities peculiar to itself which are likewise impossible of comparison with the other type of craft.**

	NC Plane	410,000-Cu. Ft. Airship
Length, ft	68	260
Breadth, ft	126	60
Height, ft	25	70
Gross lift, lb	28,000	28,000
Useful lift, lb	12,100	12,100
Average maximum speed, knots	84	84
Average cruising speed, knots	61	61
Average low speed, knots	55	37
Gasoline consumption at maximum speed, lb. per hr	800	1,000
Gasoline consumption at cruising speed, lb. per hr	420	390
Gasoline consumption at low speed, lb. per hr	390	110
Total range at maximum speed, nautical miles	1,010	760
Total range at cruising speed, nautical miles	1,420	1,510
Total range at low speed, nautical miles	1,360	3,259
Brake-horsepower at maximum speed	1,600	2,000
Brake-horsepower at cruising speed	840	780
Brake-horsepower at low speed	780	200

If we want to accomplish a thing badly enough, however, there are usually ways and means, if we build large enough on the one hand, or put in power enough on the other hand. Hence I am assuming an airship to have the same lift as the NC type of plane and to travel at equal speed. By so doing we get the accompanying data of comparative performance.

It is thus possible to get an idea of the comparative performance, possibilities and limitations of each type of craft for the particular size. You will notice that at cruising speed the airship is only slightly better. From the standpoint of efficiency and the range they are approximately the same. The speed at which they become of equal performance in that size is approximately 64 knots, or 74 m.p.h. With only the operating crew and carrying no cargo, the seaplane and airship are both about equal in performance. For revised or enlarged designs, permitting a corresponding change in performance, we arrive at the following conclusions, from a qualitative standpoint:

(1) For higher speed the airplane is better
(2) For larger loads the airship is better
(3) For larger range the airship is better
(4) As the size increases, the speed at which the airship and airplane perform equally also increases. For instance, if it were practical to build an airplane to lift as much as the R-34, the airship would be superior up to speeds well over 100 m.p.h.

It is interesting to note the difference in the overall dimensions given above. The advantage of the airplane in this respect is, however, overcome with increase in size. The figures on the seaplane are worked up from data submitted by Commander Hunsaker. A reliable comparison of costs is not yet available.

PRESIDENT C. M. MANLY:—There are two sides to the aircraft matter, the heavier-than-air and the lighter-than-air; both types have their uses and the airship is very thoroughly coming into its own for its own particular purpose.

As Commander Hunsaker points out in the paper, on the NC they put the calculated factor of safety down much below what they usually allow in the more speedy machines. He tells us that the factor of safety in the more important members, like the wing-beams, is cut to 3, whereas in the usual airplane, like the small scout that dives and turns over in the air, the factor of safety runs anywhere from 6 or 8 to 12. Spruce will withstand about 6000 lb. per sq. in. compressive stress in a select specimen. Most of the figures in the calculation of the strength of parts are based on about 5000 lb. for spruce, and of course that means with a factor of safety of 5 figuring to stress the parts to only 1000 lb. With ash the compressive strength is a little higher than with spruce, but of course ash has a very valuable property that spruce has not, withstanding much distortion without breaking. The ash strut will bend shortly before a spruce strut will, but it will survive more deflection. Spruce has proved to be about the most valuable aircraft wood we have ever had. In the rush of production we tried to find a substitute for it. We found that the very next best thing is Douglas fir. It is not as good as the spruce.

JOHN MCGEORGE:—How does the solid section compare with the glued laminated one?

PRESIDENT MANLY:—That is a very interesting thing.

At the beginning of the war it was useless to talk to the British or the American aircraft designers about using laminated parts. They said parts could not be laminated because of the joints. That was partly due to the fact that we did not have nearly as good glues or cements as we had later. The best waterproof cements were the Russian. Considerable development work was done. Later practically all of the aircraft designers preferred the laminated to the solid construction because it enabled them to be more certain of pieces like wing-beams. An inspector might fail to find spiral grain in one piece, but the chance that he would make the same error in six laminations was very small. With the development of excellent glues and cements the laminated structure really became very much better than the solid one. The effect on the available supply of timber was very great indeed.

H. W. SLAUSON:—I notice from Commander Hunsaker's paper that when the NC-3 was changed from the three-engine to the four-engine design, the fourth engine was made a pusher, leaving the other three tractors. Is that usual with four-engine design?

PRESIDENT MANLY:—It is not usual nor necessary. In this case, using the same general design, they had to put on the fourth engine to get the greater mass off the water. There is a peculiar thing about getting a boat off the water. For the actual work a pusher is better than a tractor. The pusher has not as much obstruction in the slipstream as the tractor. With a tractor propeller it is somewhat like a man trying to lift himself by the bootstraps. The reaction of the forces on the parts in the slipstream of a tractor propeller tends to hold the craft down. With a pusher, especially if the nose of the boat be inclined up slightly and the propeller pointed down a little, the effect of the air from the slipstream gives a better thrust in getting it off the water.

On the four-engine triplane we built for the British in 1915-16, the four engines were all arranged as tractors. The inner two were about 10 ft. apart, and the outer two 10 ft. distant on either side, the four engines being in a line across the machine. The four-engine super Handley-Page plane had two in front and two behind, in line with each other. The rear propeller is always given a higher pitch, because it has to work in the slipstream of the propeller in front of it. Of course, if the front propeller stops, the rear propeller works at a disadvantage, without the slipstream, and is therefore not as efficient.

RELATION OF THE TRACTOR TO THE IMPLEMENT

BY E. A. WHITE

THE author considers the adaptation of farming implements to the farm tractor the most important engineering problem confronting tractor manufacturers. The problems are intricate in their ramifications, all-inclusive in their scope and fundamental. They can never be solved by theoretical discussion and laboratory tests alone. Extensive field experiments are needed with the machines operated by the farmers themselves. It is the implement which does the work. The mold-board plow and the disk harrow are standard for soil preparation; the oscillating sickle, the reel and the knotter-head for harvesting; the revolving toothed cylinder and the oscillating rack for threshing. Power must be transmitted to these fundamental devices. The automotive tractor fills a place in the farm power field not successfully covered heretofore by any single prime mover. It furnishes power for both belt-driven and tractive machines, the latter in large number and operating under a wide variety of conditions with varying power demands.

The tractor industry is not unanimously agreed today on the range of farm operations which one prime mover should be able to cover. As a minimum it must be adapted to operating soil preparation, harvesting and belt-driven machines. Row crops are purposely excluded from this classification, since all such work and all hauling should be done by specially designed machines like motor cultivators and trucks.

Four definite lines of development are suggested. The rapid depreciation of both tractors and implements leaves little room for argument over the need for improvement in the quality of the materials used in construction. This once secured, the mechanical efficiency and speed logically follow. Already there is a noticeable tendency toward increase in both the size of the machine used and the rate of doing the work. It becomes a question of economic balance between the size of the outfit and the speed.

One man should be able to drive the outfit and make the needed adjustments of the parts while in motion. He should center his attention on the work to be done rather than on the tractor. A genuine one-man outfit would be secured by driving the machinery directly from the engine instead of from a bull wheel running on the ground. Plowing, seeding and harvesting are discussed in detail by the author in the light of both tests and actual field work, and practical suggestions are made covering such weak spots as side draft, vertical angle of hitch, satisfactory work at higher speeds, design of plow bottoms and width of swath. [Printed in the July issue of THE JOURNAL]

THE DISCUSSION

J. L. MOWRY:—Mr. White makes a classification of tractors which I believe is very close to what is going to be the situation eventually; that is, a class of heavy-duty tractors for open field work, such as plowing, seeding and harvesting, and another class of tractor that will apply directly to row planting and cultivation.

The author's first point is improving the quality of materials used in tractors and implements. The thing which comes to my mind in that connection is an effort on the part of a number of agricultural implement manufacturers to determine why one particular line on the market was having less trouble and giving more satisfaction than others. Men were put into the factory to determine what the process was; what sort of a formula they used to get the results. There was no secret; there was no formula; the only thing they were doing was to use new material instead of reclaimed material from the junk pile.

I want to emphasize the next point, increasing the mechanical efficiency of tractors and implements. That is being done as rapidly as the manufacturers can be made to believe that the farmer really wants a good implement, that he is willing to pay for it and that the price is not the deciding point in the machine that he buys. It is really too bad that so large a percentage of the farmers are "unsuccessful farmers." The successful man wants just as good an article as the man with perhaps ten times the money to purchase goods.

Mr. White's third point is increasing the rate of doing work by more speed or larger outfits. I attended the meeting at which the S. A. E. standard tractor speed was determined upon and recommended. I want to go

on record here as being opposed to it. I was opposed to it at the time of the meeting. I would not use a team of horses or a tractor that would move in the field at only $2\frac{1}{2}$ m.p.h. That is too slow. My idea is 3 to $3\frac{1}{2}$ miles, with the emphasis on the larger number. We must have more field speed.

It is my conclusion that the small outfit, what you may know now as a two-plow outfit, really has no place, and will soon become obsolete. The three and four-plow outfits will predominate and the former will take second place. The eventual type may be a three-plow machine, but it will be about the size of the present four-plow because we must have more field speed.

Mr. White has mentioned the conditions under which the heavy agricultural load must be carried, that plowing, harvesting and seeding can be done only at certain times. It is difficult to arrive at a definite figure that will show what has been gained or what can be gained by having plowing done at a certain time as against having it done at another time on the same land. It is a somewhat theoretical proposition, and yet it is susceptible of sufficient demonstration to leave it really beyond question that the larger outfit will come into its own, it enabling the farmer to do especially the three items of work mentioned at a time when they should be done.

I am inclined to look upon the combining of the units in such a manner as to make them more convenient for one man to operate. Mr. White has indicated one of the shortcomings, which is the additional implement investment necessary to make that kind of a complete agricultural unit a success. When a farmer has it, he has nothing that he can use with horses, if he should desire or be forced to do so by the inability of the tractor to deliver the goods at the right time. That brings up the subject of reliability. Professor Norman has mentioned the ratio of reliability of a steam and a gas engine as about 20 to 1. That is one of the discouraging things about power farming.

I would emphasize Mr. White's point that the work to be done is the important thing. The farmer is willing to buy good machines; he is willing to buy a good tractor, the best that can be made, but it must be reliable.

I want to take issue with Mr. White on his choice of the present type of tractor which he considers will be the best. He has stated that it is giving the best service, that is, between the tractor which runs one, or the only, driver in the furrow. He speaks particularly of the wide two, three or four wheel machine with two wheels, two drives, with one wheel in the furrow, thereby eliminating side draft. I want to take diametrical issue with him on that, believing that the furrow is no place for a driver, or two drivers, or four drivers in a four-wheel drive. There is danger of the soil packing. You may say that it does not amount to much; when it is only one or two, three or four of the furrows, it will take considerable time to make a complete sub-soil packing. But under the general conditions of operation the tractor is tipped and the wheels are up on edge. Those of you who have worked with wheels realize that the flat surface of the rim of a wheel is most valuable in getting tractive effort. Lugs are one thing and the machine that is tipped up is put on lugs. But those of you who have had experience with the skeleton rim will realize that you need, under most soil conditions, the holding down of the surface of the soil in order that the lugs may do their part, using a minimum length of lug. With the open-rim wheel, that surface breaks up, lacerates under the skeleton rim, and the results are not as effective as with the straight, solid rim with the lug. With the wheel tipped up on edge you are tipped up on one edge only of the rims. You get no result from the full rim, and the lugs themselves are then free to lacerate the soil underneath.

Mr. White mentions the development of a plow that will be more closely attached to the tractor, one which will eliminate the front wheels, the front of the plow being carried directly upon the tractor. I would take issue with Mr. White on that, as most of you can discern, if you go out and see what the present efforts in that line are doing. If our plow people know anything about manufacturing plows, and I believe they do, you will have to agree with them that a plow has to float in the ground. When you hang one end on the tractor it cannot float. There must be between the tractor and the plow a linkage that will allow the plow to float freely. The author mentions the weight of the front end of the plow that can ordinarily be carried by the wheel as being a possible addition to the rear weight of the tractor, thereby increasing efficiency. The ultimate drawbar pull of a tractor is determined by the balance of weight between the front and the rear wheels. The front rises and the drawbar has reached its maximum pull. We have to stop somewhere short of that in order to be able to steer. If this contention of adding weight to the rear of the tractor will hold, we will have to conclude that the tractor is not designed as well as it should be.

Mr. White speaks justly of harvesters, as one of the machines that needs attention. He says: "Harvesting machinery needs to be improved in such a manner that the rate of cutting can be increased without causing such rapid depreciation as occurs today. This means better material, refinement in design, stronger frames, and a decided improvement in the bearings." You know that the average age of a harvester in acres is somewhere around 800, varying from 700 to 900. The last machine that I used was put over 1700 acres, and when sold brought more cash than it had cost originally. I know that you could not do the same thing with the present harvester.

In the last paragraph of the paper belt work is mentioned as being a practically negligible quantity, a matter of pulley speeds. In Minnesota and the Dakotas the belt work is from 15 to 50 per cent of the day's work or hours of work which the tractor is called upon to do. The tractor designer must put the belt pulley where it can be used.

In conclusion, I would emphasize the fact that the tractor is distinctly an agricultural machine. I do not mean to imply that it is not an engineer's job in design and development, for it is distinctly so. What I mean is that the designer should be fully cognizant of the farmer's attitude toward agricultural implements.

L. W. CHASE:—Mr. White has presented some excellent ideas and one or two new thoughts. His discussion of the durability of the tractor should, however, have been modified by a statement of the conditions under which the tractor is compelled to work and have given the tractor the benefit of the many careless and inexperienced operators.

No doubt at this time the largest number of our tractors are made of the very best material that science can devise for engineering purposes, and yet, as Mr. White states, the tractors are not durable. This condition clearly exists because the load on a tractor engine is irregular and nevertheless as strenuous as that on any stationary engine. Furthermore, it must work continually in the dirtiest, dustiest, grittiest atmosphere of which

it is possible to conceive. In addition, the operators of tractors have worked previously with machinery that was not constructed to prevent cutting out by dirt and grit, hence they do not know the necessity of keeping all such particles away from all the bearings of tractors. Neither do they realize the importance of keeping the tractor clean and always in perfect condition. At present, the operator has as much to do with making the tractor durable as do the materials of which the tractor is constructed.

WORKING PROCESSES OF INTERNAL-COMBUSTION ENGINES

BY C. A. NORMAN

A NEW type of automotive engine should be the quest of all designing engineers. Investigation has revealed the fact that 68 per cent of all tractor engine troubles occur in magnetos, spark-plugs and carbureters, the accessories of the present-day automotive engine. Four-fifths of the fuel energy supplied is regularly wasted, yet the fuel is a liquid meeting severe requirements of volatility, etc., and is already becoming scarce and costly. In an airplane, fuel is carried by engine power. In ocean-going cargo vessels it increases available revenue space. It is at once clear that for purely practical reasons the question of fuel economy, no less than the question of the nature of the fuel, becomes momentous. What fuel will do is entirely a question of what process it is put through in the engine; in what way combustion is turned into power.

In the paper the physical processes underlying the conversion of combustion energy into power are discussed, together with the various methods for producing the pressure differences needed for the operation of ordinary heat engines. The author states both the theoretical and the practically attainable energy utilizations of engines and turbines, of the compressor, explosion and evaporation types. Improvements are found to be obtainable in all three types and some suggestive lines of work are pointed out. Among these the compressor engine and the steam powerplant offer interesting possibilities in competition with the work already done by the Brayton, Kraus and Armengand-Lemale engines. In connection with the investigation of electrical combustion batteries, the author asks whether it would be possible to use the combustion process with our ordinary fuels to deliver electric current in a primary battery, and what the fuel utilization of such a battery would be. It is known that from 1910 to 1912 Baur, Taitelbaum and Ehrenberg, in Germany, succeeded in combining such fuel batteries and obtaining electromotive forces close to those theoretically possible. [Printed in the July issue of THE JOURNAL]

THE DISCUSSION

W. G. GERNANDT:—As Mr. Norman has pointed out, there are various ways in which the ideal result of the transformation of heat into the maximum amount of mechanical work is being approached. The selection of a best working process or cycle for an internal-combustion engine is difficult and requires the combined efforts of engineers and scientists. The word cycle is used in this discussion, because in the action of any heat engine the working medium passes through various stages of compression and expansion and finally returns to its initial state as to temperature and pressure. The combination of these stages in an engine, therefore, represents a cycle of operation, whether the resulting pressure-volume diagram is closed or open.

The internal-combustion engine being fundamentally a heat engine, the selection of a best cycle should be based upon the original Carnot reversible cycle, because this produces the highest efficiency theoretically attainable with any heat engine. In this engine, could it be produced practically, heat is supplied at a constant temperature, expansion takes place without gain or loss of heat, exhaust takes place at a constant temperature, and compression takes place without gain or loss of heat, bringing the final temperature up to the starting point. With this combination of isothermal and adiabatic curves for the pressure-volume diagram, the entropy-temperature diagram becomes a rectangle, indicating that for a given temperature range the maximum mechanical work has been obtained from the heat supplied. Of course no internal-combustion engine can operate on this theoretical cycle, because it would require all the exhaust gases to return to their original state by passing through the various stages of compression and expansion in a reverse direction. As the reciprocating engine with its practically closed cycle of operation approximates this theoretical cycle, it is well to begin all calculations and compressions from this point.

A careful study of the thermodynamics of the internal-combustion engine reveals the fact that to obtain the maximum thermal efficiency it is necessary to introduce each heat element at the highest possible pressure and to exhaust at as close to atmospheric pressure as possible. This brings us to the point of selecting that method of combustion which will allow for this maximum efficiency. It has been proved both theoretically and practically that, with the compression pressure equal in each case, combustion at a constant volume is more efficient than at a constant pressure because the heat is supplied at a greater average pressure. However, conditions are reversed if the compression is raised to the point of maximum pressure of the constant-volume combustion. Therefore, our logical conclusion should be to use the highest possible compression pressure to obtain the highest thermal efficiency of combustion. This leads directly to the high-compression engine using air for the compression medium and a liquid hydrocarbon for the addition of heat. Naturally there are a number of methods of actually injecting the fuel into the combustion chamber, but the ideal one should possess the following features, which can be incorporated in an engine without undue complication or extreme care in manufacture:

(1) Mechanical control of the quality of fuel injection

(2) Mechanical control of the time of fuel injection

(3) Mechanical control of the rate of fuel injection

(4) Addition of heat to the fuel prior to and during injection

(5) Thorough atomization of the fuel during injection

(6) Thorough commingling of the fuel and the air during combustion

The question of obtaining greater expansion is one of much interest and should receive considerable attention,

but a point well worth considering is whether the complication of added weight and multiplicity of parts will offset the gain due to increased expansion.

I agree with Mr. Norman that, to get the best results in the development of the internal-combustion engine, the service of scientifically trained men should be obtained to give undivided attention to a systematic research of the fundamentals underlying combustion and the transformation of heat into mechanical work.

O. H. ENSIGN:—I have attempted to get a constant-pressure cycle. Laid down from the drawings, the engine operated the first time on the cycle and it has continued to do so. In trying to eliminate the losses that occurred in the engine as far as possible and to get rid of the back-fire problem, I attempted the almost impossible feat of introducing the air and the fuel separately and drawing in the fuel by the energy developed in a peculiar method of introducing the air. This seems to have worked, but I have not gone far enough to state more than that the volumetric efficiency is encouraging, somewhere near perhaps that of the present automotive apparatus. The engine has run a sufficient number of hours to prove that it starts under full torque and with the Corliss engine valve used retarded ignition is bound to occur, which means a slight explosion at the beginning of the stroke at times; but these back-fires have done no harm to the valve. I cannot claim anything at all except that the engine has pulled the load, starting from rest under full torque, can be reversed instantly and responds to instant cut-off. I know nothing as yet as to its performance, except that the exhaust is clean.

W. A. FREDERICK:—We have been wrestling with the question of fuel economy for a number of years. Perhaps Professor Norman's theory will eventually solve the problem. Perhaps by working along the way we have been going we shall eventually get there in a different way by following along different lines. The tappet adjustment in an engine has a very decided bearing on fuel economy. It is a little thing, but to my way of thinking it has a very important bearing on the subject. We work along in the laboratory and develop a new engine and get certain results. We then turn that engine over to the public and shortly we hear that they are getting entirely different results. I undertook some time ago to find out the reason some users were not getting the same results we got in running apparently the same tests. I found, much to my surprise, that the little screw used for a tappet adjustment is one of the biggest offenders. Here is exactly what happened. In an effort to get a quiet engine, the owner adjusts this little screw up real close and by so doing makes the valve ride. When the valve begins to ride, the first thing that happens is poor compression in one cylinder. A little later on that cylinder starts to miss. Sometimes the operator will not find out where the trouble is and will run the engine with one of the cylinders missing. I think that nothing is more contributory to pumping gasoline down into the crankcase than having one cylinder missing. The gasoline goes down into the crankcase and dilutes the lubricating oil. Immediately we have an oil that has scant lubricating qualities. The piston-rings and pistons begin to wear, there is more room between the piston and the cylinder for the gasoline to run down, and the engine becomes worn-out. I think I am safe in saying that one little thing like a tappet adjustment is one of the principal causes of the whole trouble.

CHAIRMAN H. L. HORNING:—I can verify Mr. Frederick's statement, because we have had similar experiences. He has not, however, mentioned one thing, and that is that just as soon as an exhaust valve rides, wire-drawing, as some engineers used to call it, commences and the temperature of the valve rises very rapidly and gets beyond control, and if it is a steel valve, even of the tungsten steel type, the valve will be cut to pieces or warp into a concave form. We have had a number of valves returned with the comment that they were no good, because the push-rod adjustment was wrong. I remember the time when the steam engine was considered stabilized and standardized. We had the triple-expansion compound engine, which was considered to be the highest type of prime mover. It was not long ago until we got the steam turbine, which increased the efficiency to a marked degree. Probably we are right on the eve of a similar move in the gas engine industry. I know that no one will welcome it more than the man in the factory, the engineer who has to satisfy the public with his product.

The automobile engineer, in common with all men, has his troubles. I sometimes think we have more than our fair share.

In regard to the fuel situation, I believe the chemist has been rather sidestepping the issue. One of my friends, who has conducted considerable investigation, tells me that the mere mixing of alcohol with petroleum products eliminates one of our most serious difficulties at the present moment, "detonation." This detonation is working contrary to efficiency. We increase the mean effective pressure and immediately we get into trouble with detonation, which causes our apparatus to become practically useless, particularly a truck engine which will pound its head off. I confidently look for an adequate supply of fuel that can be used in our present-day engine without a very great difference in the construction.

M. C. HORINE:—We hear much about gasoline pumping. I think that, aside from the design standpoint, education is needed to prevent fuel pumping into the crankcase. I believe a great cause of that is the prevalent habit of using the engine as a brake in going down hill. If you will analyze that process, you will realize that you are pumping gasoline; it does not matter that your throttle is closed, you are pumping gasoline just the same right through the cylinders which are cooled very rapidly with the result that the gasoline condenses. At the same time you are alternately making a vacuum and a compression in the cylinders, which results in drawing the oil from the crankcase into the cylinder, mixing it in with the fuel and then pumping it back into the crankcase.

We all have ratchet hand-brakes which were designed originally for locking the car at a standstill and also partially applying the brake in coasting downgrade. It is very rarely that I ride with a man who uses his hand-brake at all unless the car is at a standstill. One manufacturer has provided a selective linkage by which the foot pedal and the ratchet lever can be linked so that the foot pedal can be used to actuate both sets of brakes. One of the reasons for the lack of use of the hand-brake is our unfortunate misconception of the respective duties of the two brakes. We call the hand-brake the emergency brake and the foot-brake the service brake, whereas any driver, if he analyzes the point, knows that the foot-brake is the emergency brake. In an emergency you have no time to reach down and pull up a lever; the most natural thing is to push out both feet. If some effort were made through the technical and the popular press and by manufacturers to encourage the use of the hand-brake to hold back the vehicle, we would have less gaso-

line pumping into the cylinders. If the hand-brake is not big enough to withstand the heat, make it bigger.

C. A. NORMAN:—Mr. Gernandt's discussion contains some very concise and pertinent thermodynamic considerations. There is, however, considerable danger in applying deductions from theoretical cycles to the prediction of actual engine performance. This danger is that inefficiencies and losses are not allowed for at the particular part of the cycle where they enter and that in consequence their influence is very often seriously miscalculated. This has been illustrated with particular force in the history of the continuous-combustion type of engine, but applies also to the constant-volume type. It is well known that the efficiency even theoretically obtainable with actual combustion gas may be some 20 per cent lower than that indicated by the ideal thermodynamic cycle. This is due simply to the variations in specific heat. In my practical research work I have, therefore, always made it a principle to investigate the actual process step by step, and have thus been able to explain many apparently mysterious discrepancies between theory and practice.

With regard to the correct attitude of practical engineers toward engineering progress, I can only voice my heartiest sympathy with the feeling of need of intensive application to detail perfection. Especially is it necessary to impress upon the rank and file of young engineers that for steady progress, scientific study and improvement of existing types, engineering, in a word, is needed in a vastly greater amount than invention and everlasting tinkering with new and untried ideas. However, as emphasized some time ago by B. G. Lamme, the great engineer is the man who knows exactly when to let go of his design. We are living under continually changing conditions. No matter what our private interests are, instinctively every engineer must be a friend of progress. There will always be times when economic change, scientific progress, new discoveries and inventions will make new technical developments inevitable. The wise engineer is the one who foresees these developments and is ready for the new step when it becomes advisable.

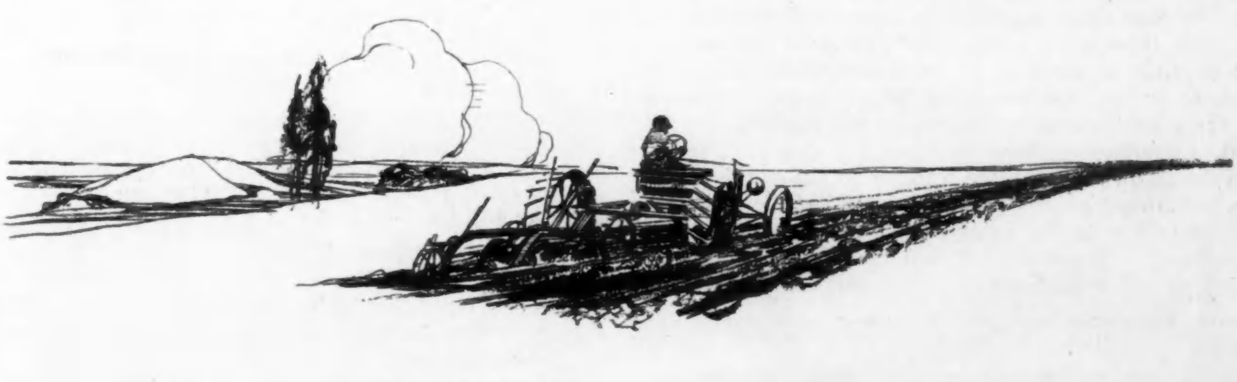
MEMBERSHIP ROSTER FOR 1919-20 READY

THE 1919 Membership Roster is now ready for distribution to the members who can secure copies on application to the New York office. The general arrangement of the list of members is the same as that followed in the 1918 edition, containing an alphabetical register of the members, a list of the companies with which the members are connected (also arranged alphabetically) and a geographical register that gives the names of the members residing in the various towns and cities of the United States and in different foreign countries. A list of the officers and members of the Council and the personnel of the 1919 Administrative and Standards committees are included, together with a list of the officers of the Sections of the Society for this season.

The pamphlet contains 237 pages as compared with 194 in the 1918 edition. This serves to measure the increase in the membership of the Society which numbered 4079 on June 30, 1919, as compared with 3326 on July 20, 1918, and 2877 on Oct. 1, 1917. The increase in the number of companies represented by members of the Society is not as large as it was last year, the figures being 1696 for 1919, 1527 for 1918 and 1179 for 1917. The number of universities represented in the membership is almost double that of 1918, 42 as against 25 for 1918 and 11 for 1917.

The membership is distributed over forty-three states and territories and the District of Columbia and fifteen foreign countries. The states in which members are listed for the first time are Hawaii, Louisiana, Utah and Wyoming. The foreign countries represented for the first time include Belgium, China, Finland, Scotland and the West Indies.

One of the most interesting features of the statistics of residents is the relative number of members in those states which include the larger automotive centers in this country. It is somewhat surprising to note that there are more members residing in the State of New York than in any other state, these aggregating 742. Michigan follows with 642. Next in order of number of members are Ohio, 563; Illinois, 341; Indiana and Pennsylvania, each 255; New Jersey, 204; Massachusetts, 165; Wisconsin, 142; Connecticut, 103. There are nearly a hundred members of the Society engaged in automotive activities in California. There are upwards of a hundred in Minnesota, engaged in farm tractor engineering and production for the most part. Several hundred members were located at Washington during the war, but now the number is much less, of course. It is expected that more than fifty will reside there permanently. The actual number will depend largely upon the extent to which those engaged in engineering work for the Government take advantage of the Service Membership in the Society and the extent to which the Government avails itself of Society Departmental membership.



The Horsepower of Resistance in Airplane Design

By N. L. Lieberman[1] (*Member*)

Buffalo Section Paper *Illustrated with* Charts and Photographs

THE problem of the resistance of an airplane has received, directly and indirectly, the analytical attention of many of the celebrated mathematicians and physicists of the last and present centuries. The researches of Newton and Bernoulli have given the general laws of motion and pressure, Euler presented the laws of fluid motion from an investigation of all the points occupied by the fluid, at all instants, while Lagrange explored the same field by investigating the motion of an individual particle. To Lord Kelvin we are indebted for his general dynamical principle. Helmholtz first solved the flow of fluids bounded partly by fixed walls and partly by surfaces of constant pressure and developed the formulas of vortex flow; then independently and almost simultaneously Helmholtz and Kirchoff established the theory of discontinuity flow. In 1902 Kutta brought forward his vortex sustentation principle for arched surfaces. A partial explanation of turbulent or eddy motion was presented by Prandtl. The elaborate mathematical analyses of Laplace, Raleigh, Schwartz, Christoffel, Rankine, Stokes, Lanchester and Lamb, and the experiments of Langley, Lanchester, Föppl, Prandtl, Reynolds and Zahm, have all contributed to a directive understanding of the phenomena of fluid motion. No attempt is made here to expand any of the above-mentioned theories. Complete discussions, showing the derivations and limitations, are given in Lamb's Hydrodynamics. An excellent résumé showing the salient features of each theory and the mathematical concepts was presented in 1915 by J. C. Hunsaker in his paper, A Review of Hydrodynamical Theory as Applied to Experimental Aerodynamics.[2] It is of interest, however, both academically and for guidance in experimental work, to know the results obtained by these various investigators.

Fluid Motion

To establish a basis for analysis, an ideal fluid of mathematical definition has been adopted. From the theoretical results thus obtained, approximations are predicted for the behavior of real fluids. A brief review of the derivation of the general formulas for fluid motion will aid in understanding the broad aspect of the problem and further show the relation between the theoretical conclusions, laboratory models and full-scale findings.

If a particle of mass m be subjected to the action of extraneous forces, various physical phenomena, according to the conditions of constraint of the particle, are developed. Considering the constraints, if existent, as not subject to distortion, a force applied to the particle will induce motion which may be limited either along a line, if the constraint be the intersection of two surfaces, or on a surface, in any direction, but always subject to the condition of being contiguous to the surface. If no constraining conditions exist, the particle is considered to have free motion. In addition to inducing motion, the applied force will set up the reactions of inertia in the mass m. This latter statement is expressed in D'Alembert's equation

$$F - \frac{d^2s}{dt^2} = 0 \qquad (1)$$

indicating that the inertia forces are equal and opposite to the applied forces inducing motion or change of motion.

Let the particle of mass m, subject to the action of the force F, be referred to three rectangular axes X, Y, Z, such that its coordinates be x, y, z. The point of application of the force F will also be considered at x, y, z. If, then, under the action of the force F, the particle moves over the distance δs, along the line mn, at an angle ϕ to the line of force, we will use the following symbols for references:

δs = distance over which particle travels, due to force F

a, b, c = angles which the δs makes with the X, Y, Z axes, respectively

(α, β, γ) = angles which line of force F makes with the X, Y, Z axes, respectively

ϕ = angle between δs and line of force, F

$\therefore \cos\phi = \cos a \,.\, \cos\alpha + \cos b \,.\, \cos\beta + c \,.\, \cos\gamma$

then

$$F\delta r = X\delta x + Y\delta y + Z\delta z$$

will give the relation between the virtual work due to the applied forces and its components on the X, Y and Z axes of reference.

Similarly

$$m\frac{d^2s}{dt^2}\,\delta s = m\frac{d^2x}{dt^2}\,\delta x + m\frac{d^2y}{dt^2}\,\delta y + m\frac{d^2z}{dt^2}\,\delta z$$

indicates the relation between the virtual work of the developed inertia force and its components on the X, Y and Z axes of reference.

Since equation (1) indicates that the effective or applied forces are equal and opposite to the developed inertia forces, the virtual work done by each of these forces is also equal. We thus have the relation

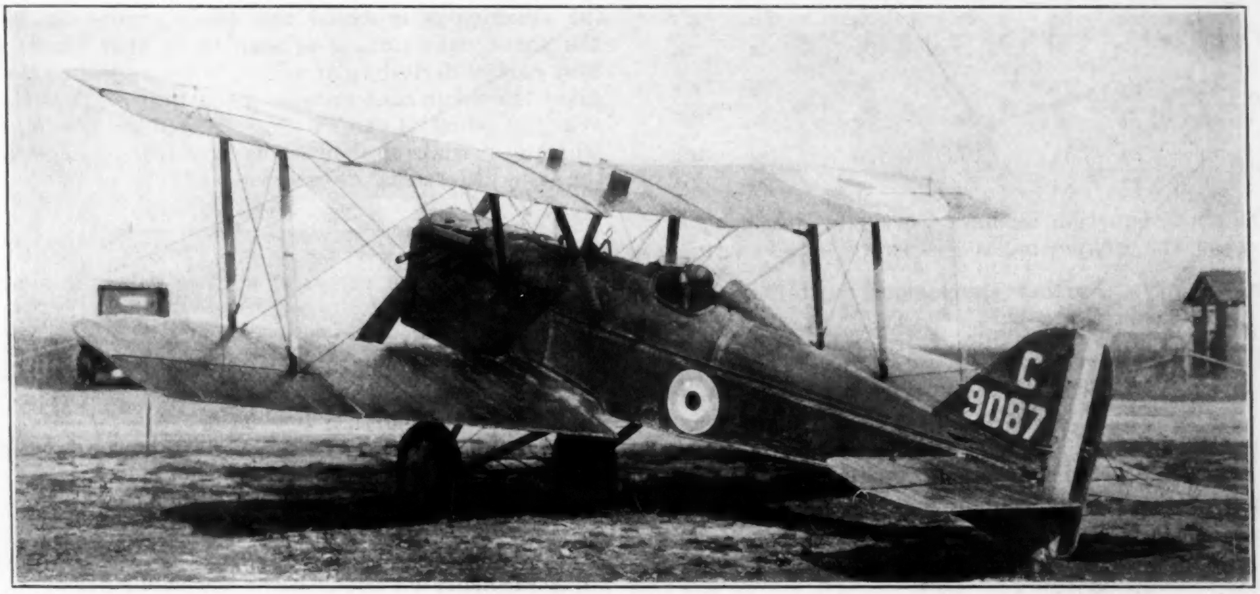
$$\sum\left[\left(X - m\frac{d^2x}{dt^2}\right)\delta x + \left(Y - m\frac{d^2y}{dt^2}\right)\delta y + \left(Z - m\frac{d^2z}{dt^2}\right)\delta z\right] = 0$$

The above equation, known as Lagrange's equation of dynamics, is applicable to free, as well as to constrained motion. Since the factors δx, δy and δz are projections of the virtual velocities on the X, Y and Z axes, if the motion is constrained, the virtual velocity must conform to certain conditions of movement, these factors must also conform to similar conditions of constraint. If the motion is free, the virtual velocity may be arbitrarily chosen, hence the factors δx, δy and δz may similarly be arbitrarily chosen.

The total pressure may be taken as due to pressure ap-

[1]Assistant engineering manager, department of education and sales promotion, Curtiss Aeroplane & Motor Corporation, Garden City, N. Y.

[2]Presented before the International Engineering Congress, September, 1915.



THE CURTISS SE-5 AIRPLANE

plied directly to the particle and pressure transmitted from any distance. This latter value is given by the expression

$$\delta p = \frac{\partial p}{\partial x}\delta x \text{ (in the } \delta x \text{ direction)}$$

with similar expressions for the δy and δz directions. If P_1, P_2 and P_3 represent the accelerations in the δx, δy and δz directions respectively, due to forces directly applied to the particle, and remembering that $m = \rho.\delta x.\ \delta y.\ \delta z$, we obtain from Lagrange's equation, by virtue of the principle of indeterminate coefficients

$$P_1 - \frac{d^2x}{dt^2} = \frac{1}{\rho} \cdot \frac{\partial p}{\partial x}$$

$$P_2 - \frac{d^2y}{dt^2} = \frac{1}{\rho} \cdot \frac{\partial p}{\partial y}$$

$$P_3 - \frac{d^2z}{dt^2} = \frac{1}{\rho} \cdot \frac{\partial p}{\partial z}$$

The velocity of the fluid particle, at time t, is generally represented by the components, u, v, w, parallel to the axes of reference X, Y, Z, and conforms to the definition

$$u = \frac{dx}{dt},\ v = \frac{dy}{dt},\ w = \frac{dz}{dt}$$

These component velocities, however, are also, in themselves, functions of the coordinates of the particle, and the time t

$$u = f_1\,(x, y, z, t),\quad v = f_2\,(x, y, z, t),\quad w = f_3\,(x, y, z, t)$$

Therefore any change in the velocity of the particle can be expressed

$$\frac{d(F)}{dt} = u\frac{\partial F}{\partial x} + v\frac{\partial F}{\partial y} + w\frac{\partial F}{\partial z} + \frac{\partial F}{\partial t}$$

from which we can obtain directly, substituting the values of u, v and w

THE CURTISS JN-4 AIRPLANE

$$P_1 - \frac{1}{\rho} \cdot \frac{\partial p}{\partial x} = \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} = \frac{d^2x}{dt^2}$$

$$P_2 - \frac{1}{\rho} \cdot \frac{\partial p}{\partial y} = \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} = \frac{d^2y}{dt^2}$$

$$P_3 - \frac{1}{\rho} \cdot \frac{\partial p}{\partial z} = \frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} = \frac{d^2z}{dt^2}$$

In the above equation we have five quantities, u, v, w, p and ρ as the unknowns, to be expressed in terms of $f\,(x, y, z, t)$. Further expressions must therefore be obtained.

Since the mass m is constant for any conditions of motion or change in physical boundaries, the condition

$$\rho.\delta x.\delta y.\delta z = k$$

must always obtain.

It can be readily shown that any variation in volume is given by the expression

$$\frac{1}{V} \cdot \frac{dV}{dt} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}, \text{ where}$$

$$V = \delta x \,.\, \delta y \,.\, \delta z = \text{volume at the time } t$$

Noting that the mass is assumed as constant, and $= \rho V$, where $V = \delta x.\delta y.\delta z$,

$$\frac{d(\rho V)}{dt} = 0 = \frac{1}{\rho} \frac{d\rho}{dt} + \frac{1}{V} \frac{dV}{dt}$$

Substituting the value of $\frac{1}{V} \cdot \frac{dV}{dt}$, we obtain

$$\frac{d\rho}{dt} + \rho \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right) = 0$$

This equation is called the equation of continuity of flow. Another form in which the equation of continuity of flow is often quoted is

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho u)}{\partial x} + \frac{\partial (\rho v)}{\partial y} + \frac{\partial (\rho w)}{\partial z} = 0$$

which is obtained for the relation $\rho = \phi\,(x, y, z, t)$, expanded for its value at time $t + \delta t$ by Taylor's theorem, and the value thus obtained for $\frac{d\rho}{dt}$ substituted in the first expression for continuity of flow.

Fluids in general are considered from either the theoretical viewpoint, in which case they are incompressible, or the actual condition, which allows some degree of compressibility. No physical body is actually incompressible, but owing to the very small changes in volume which accompany a compressive force liquids are generally classified as incompressible. There is, therefore, no change in density with any variation in time. This gives the primary condition of definition of the ideal fluid

$$\frac{d\rho}{dt} = 0$$

which gives the condition of "no increase in volume"

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

This is also the equation of continuity of flow for incompressible fluids.

We then have established five general equations for the five unknowns, u, v, w, p and ρ.

If a single function ϕ exists, such that u, v, w can be expressed by the following relation

$$u = -\frac{\partial \phi}{\partial x}, v = -\frac{\partial \phi}{\partial y}, w = -\frac{\partial \phi}{\partial z}$$

the function ϕ is called the velocity potential. From the above definition, it is seen to be that function, the first partial derivitive of which, with respect to the axes, gives the component velocity along the specific axis. The velocity potential can be thus defined as $\phi(u, v, w)$ in which u, v, w are in themselves functions of (x, y, z), and the total differential $d\phi$ is expressed

$$d\phi = \frac{\partial \phi}{\partial x} dx + \frac{\partial \phi}{\partial y} dy + \frac{\partial \phi}{\partial z} dz$$

Substituting the values of u, v, w from the above, we have

$$-d\phi = udx + vdy + wdz$$

Suppose a surface be drawn through the various points having the same value for $-d\phi$, such a surface is called an equipotential surface.

Since the difference in potential $-d\phi_1 + d\phi_2$ must be constant by definition, the amount of work done in moving a particle from the $d\phi_1$ surface to the $d\phi_2$ surface must also be constant. The maximum force at any point will therefore lie along the shortest line between the two surfaces, hence on the common perpendicular. Further, the maximum velocity of flow, or transfer, will also be along the common normal. Thus the lines of maximum force and the velocity lines are identical at any instant of time. Any line which lies on a $d\phi$ surface must satisfy the corresponding equation,

$$-d\phi = udx + vdy + wdz$$

Let AB represent such a line for the ϕ_1 surface and CD the corresponding line for the ϕ_2 surface. Further, let δc be the common normal to the two lines, AB and CD. Since the lines lie on an equipotential surface, they are called equipotential lines. If from any point (x, y, z) a line δs with direction cosines l, m, n be drawn to AB or CD, the velocity projection on AB or CD will be given by the general equation $lu + mv + nw$, since u, v and w correspond to the direction cosines of the lines AB or CD. The above value of the projection may be written

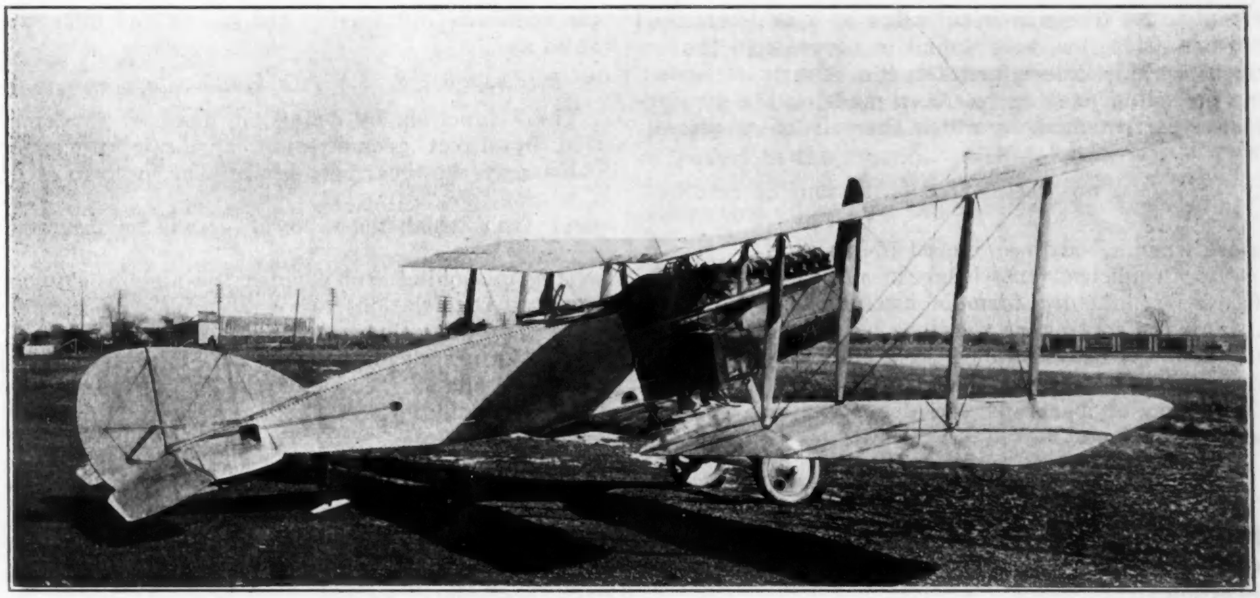
$$-\frac{\partial \phi}{\partial x} \cdot \frac{dx}{ds} - \frac{\partial \phi}{\partial y} \cdot \frac{dy}{ds} - \frac{\partial \phi}{\partial z} \cdot \frac{dz}{ds} = -\frac{\partial \phi}{\partial s}$$

The velocity along the line $\delta s = -\frac{\phi}{\partial s}$ and is equal to the variation of change of the function in that direction. If the line δs lies on the surface containing AB, there can be no rate of variation, since $d\phi =$ a constant for the surface. The velocity on the $d\phi$ surface is therefore constant.

Since the maximum velocity between the two equipotential lines will always be along the common perpendicular, the equation of the maximum velocity lines will correspond to the normal to AB or CD, hence $\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}$.

These latter lines are called "streamlines." It is thus seen that the streamlines are at right angles to the equipotential lines. The streamlines are functions of the time, as defined by the complete function $f(x, y, z, t)$.

They therefore show the continuous motion of a particle from successive equipotential lines, with respect to the disturbing body setting up the initial pressure. If the force lines be plotted, these will represent the condition of motion at any instant of time. Hence t, being constant, may be eliminated from the function, and the defining condition is $f(x, y, z)$. These lines are relative



THE BRISTOL FIGHTING PLANE

to the fluid. From the definition of the velocity potential, we have the following relation:

$$\frac{\partial u}{\partial x} = -\frac{\partial^2\phi}{\partial x^2}, \quad \frac{\partial v}{\partial y} = -\frac{\partial^2\phi}{\partial y^2}, \quad \frac{\partial w}{\partial z} = -\frac{\partial^2\phi}{\partial z^2} \text{ and}$$

$$\frac{\partial u}{\partial t} = -\frac{\partial^2\phi}{\partial x \partial t}, \quad \frac{\partial y}{\partial t} = -\frac{\partial^2\phi}{\partial y \partial t}, \quad \frac{\partial w}{\partial t} = -\frac{\partial^2\phi}{\partial z \partial t}$$

which, substituted in the general equation for the total component forces, finally yields the equation, when the second power of the small velocities are neglected

$$\frac{dp}{\rho} = P_1 . dx + P_2 . dy + P_3 . dz - d\left(\frac{d\phi}{dt}\right)$$

If the particles of fluid are not acted on by extraneous forces, we have

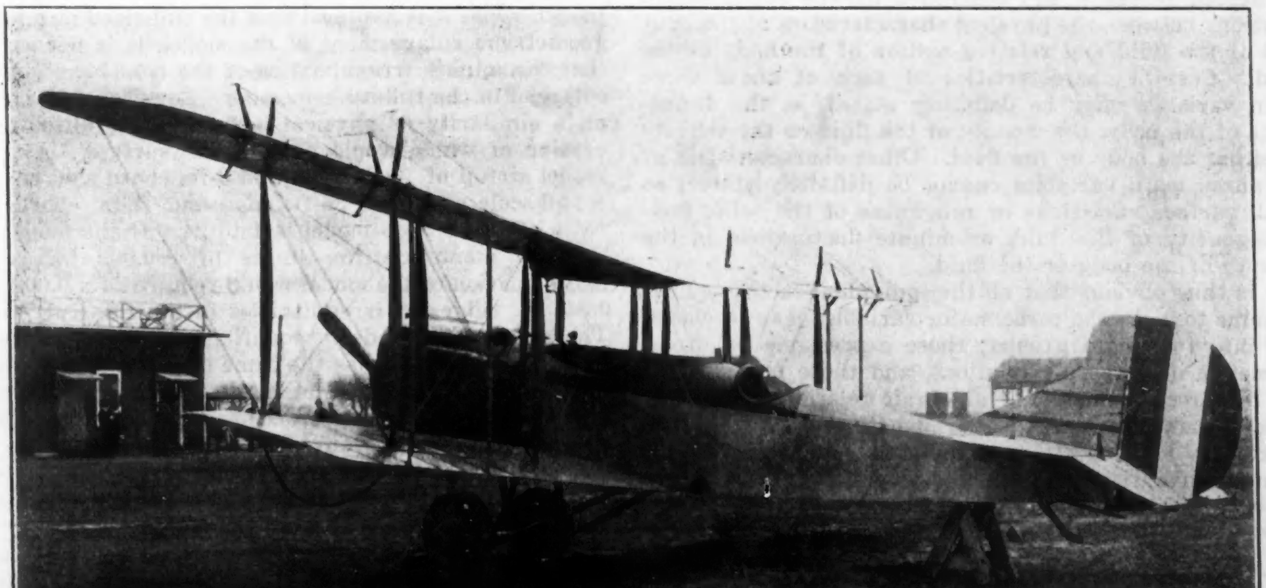
$$\int\frac{dp}{\rho} = \frac{d\phi}{dt} = C^2S, \text{ in which } C^2 = \left(\frac{\rho}{\rho_0}\right) \times \frac{dp}{d\rho}$$

and S is given by the relation $\rho = \rho_0(1 + S)$, ρ_0 being the density in the undisturbed condition, and S is called the condensation. From the above relations, in connection with the second expression for continuity of flow, we have

$$\frac{\partial^2\phi}{\partial t^2} = C^2\left(\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2}\right)$$

or, using ∇ to indicate $\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}$, $\frac{\partial^2\phi}{\partial t^2} = c^2 \nabla^2\phi$

In the above equation c represents the velocity of propagation in the medium, and the equation is the general equation of sound waves. Since $\int\frac{dp}{\rho} = \frac{d\phi}{dt}$, the equation of motion indicates the compressibility of the fluid under motion. Thus the compressibility is pro-



THE CURTISS R-4 AIRPLANE

portional to c. The numerical value of c as determined by its definition, has been found to agree with the experimental value determined for the velocity of sound.

The preceding analysis has been made on the assumption of a perfect fluid, in which there is no compressibility, $\frac{\partial p}{\partial t} = 0$; no viscosity, $\mu = 0$; and no resultant pressure when a body was moved in the fluid, $\nabla^2\phi = 0$.

Due to insufficient knowledge in mathematical operatives, no satisfactory formula has yet been developed that states the continuous relations between the physical constants of the body contour, the attitude, the fluid, the velocity and the reactions. Model study has thus been made the major basis of the determination of aerodynamic coefficients.

Model Study and Dynamical Similitudes

The general condition of translational motion in one direction of a solid has been expressed by D'Alembert in the equation

$$M\frac{d^2s}{dt^2} = F, \text{ where} \qquad (2)$$

M = total mass of body

$\frac{d^2s}{dt^2}$ = change of rate of motion of mass M

F = impressed forces

$M\frac{d^2s}{dt^2}$ = effective forces

Since this equation is independent of any assumption as to the character of the mutual actions and reactions between the particles, it is applicable to fluids as well as to solids. The problem, briefly stated, is the determination of the relations between the impressed forces on a full-scale body of three dimensions and its geometrical model.

Inasmuch as equation (2) defines the motion as relative, the conditions are satisfied either if the body be moved through the fluid at a velocity v, or if the fluid move past the stationary body at a velocity $-v$. The impressed forces F are controlled by the statement of relations between the physical characteristics of the body and of the fluid and relative motion of the body or the fluid. Certain characteristics of each of these three main variables may be definitely stated, as the dimensions of the body, the density of the fluid or the velocity of either the body or the fluid. Other characteristics of the three main variables cannot be definitely stated, as small surface variations or roughness of the solid, nonhomogeneity of the fluid, or minute fluctuations in the velocity of the body or the fluid.

It is thus obvious that all the individual factors which combine to make the three major variables may be classified into two main groups; those expressible by direct geometric or algebraic relations, and those not expressible by direct geometric or algebraic relations. In algebraic nomenclature we usually denote relatively known factors by the first letters of the alphabet, and relatively unknown quantities by the last letters. Thus, equation (2) may be expressed

$$M\frac{d^2s}{dt^2} = F = f\,(a, b, c, d \ldots u, v, w, x, y, z) \quad (3)$$

The above general equation may be restated to indicate the definite influence of the known variables and the indefinite influence of the known and unknown variables as

$$F = \phi\,(a, b, c, d \ldots)\ \psi\,(a, b, c, d \ldots u, v, w, x, y, z) \quad (4)$$

The ψ function, by definition, does not render a solution by direct geometric or algebraic processes. Its value may, however, be determined by test or experiment, from which the value $M\frac{d^2s}{dt^2}$ will be observed. Deductive reasoning will furnish the algebraic form of ϕ, hence all the relations are established. By sufficient experiments, the influence of the known variables may ultimately be practically formulated. However, such terms as "smoothness," "eddy-formation," or minute fluctuation in the fluid viscosity do not permit of direct comparison, since, physically, they are beyond control. The absolute existence of physical perfection would cause the unknown parameters v, w, x, y and z to disappear, since they would be equal to zero as influences in the function. However, although physical perfection is not obtainable even in the finest of model work, those various characteristics represented by these latter parameters v, w, x, y and z may be made sufficiently close that in any two experiments the result shows independence of their influence. In other words, the test is reduced to the equivalent physical problem wherein the mechanical limitations of manufacture are not considered and the bodies are ideal. For comparative analysis, therefore, and to permit a determination of model laws, it is assumed that the unknown variables become constants for all conditions of test. That is to say, in any successive tests on different sized models, or models and full-scale members, it is assumed that the surfaces have the same degree of smoothness, that the motion-fluctuation is the same in each, etc. Hence the influence of these variables is arbitrarily removed from the physical results, and equation (4) reduces to

$$F = \phi\,(a, b, c, d \ldots)\ \psi\,(a, b, c, d \ldots) \quad (5)$$

Before passing further from the influence of the factors (u, v, w, x, y, z) represented typically by "smoothness," the following point will be brought out: In the discussion of a full-sized member as compared with a model, while it is assumed that the full-sized member is a geometrical enlargement of the model, it is not assumed that the minute irregularities of the model are similarly enlarged in the full-scale member. Equation (5) is based on a similarity of physical boundary, the ultimate conception of which would be a "true" surface. Assume a model airfoil of 18-in. span and 3-in. chord as a basis for a full-scale airfoil of 36-ft. span and 72-in. chord. The ratio of full size to model is 1 to 24. If the model were built to manufacturing limits of ± 0.002 in., a true magnification of the model would require 24 x 0.002 in. = 0.048 in. ridges or irregularities in the full-scale airfoil. The assumption made in equation (5), however, is that the full-scale airfoil has the same ultimate surface as the model. While this is not a probability, the variation therefrom in actual construction does not exceed the allowable magnification surface, and for this reason, it is considered that the surfaces of both model and full-scale members are identical. The same parallel applies to the other variables removed from the equation.

A detailed examination of the characteristics involved in the complete definition of the body, fluid and motion shows that only eight are ultimately needed to completely identify the motion for model study. These eight characteristics are

$M\dfrac{d^2s}{dt^2} = F =$ force developed
$L =$ span of airfoil
$\epsilon =$ elasticity of airfoil
$\rho_1 =$ density of airfoil
$\rho_2 =$ density of fluid
$\psi =$ kinematic viscosity of fluid
$C =$ compressibility of fluid or velocity of sound in fluid
$V =$ velocity of advance of body or fluid

These terms are then treated in accordance with the theory of dimensional homogeneity. The basic principle of this theory is that all terms of an equation must be expressed in the same system of units. The M, L, T notation is here used.

Inasmuch as the treatment is qualitative, it is possible to express any equation denoting force, motion or work in the above units, since the factors of such equations must ultimately be based on these three quantities. If a series of factors combine to express a given phenomenon, the quantitative influence of each may not be explicitly given by the conditions. The index to the degree of influence which each factor for the given set of conditions exerts may, however, be indicated by an exponent, the value of which may or may not be ultimately determined. If the conditions imposed are self-contained, the exponents can be readily determined. If more operating conditions are required than are stated in the problem, the exponents are not all completely determinable and yield a general factor of directive influence.

The physical equation

$$f\left(M\frac{d^2s}{dt^2}, L, \epsilon, \rho_1, \rho_2, \phi, C, V\right) = 0$$

yields the final general expression

$$M\frac{d^2s}{dt^2} = F = \rho_2 L V^2 \psi\left[\frac{LV}{\phi}, \frac{V^2\rho_2}{\epsilon}, \frac{\rho_2}{\rho_1}, \frac{V}{C}\right] \qquad (6)$$

If the velocities of test do not approach the velocity of sound in the medium of test, and further, if the medium of test is the same as the medium of flight, the ψ function reduces itself to a consideration of the L and V factors. Since for any given model L is constant, and for critical speed conditions we are governed by the relation $\dfrac{V}{V_m} = \dfrac{L_m}{L}$ (where L_m and V_m refer to the line or dimension and velocity of the model), the Ψ function becomes a constant. The statement for resistance is then given by the equation

$$F = K\rho_2 L V^2$$

wherein K combines the effects of cross-section of the body, covering attitude to flow of medium, etc. It is thus called the "form coefficient." For bodies other than of airfoil type, interest lies mainly with the coefficient of resistance.

Coefficients of Resistance

In 1912 the National Physical Laboratory, Teddington, England, tested a series of proposed strut sections submitted by Mr. Ogilvie and obtained interesting results. In Fig. 1 I have assumed that a condition of continuity exists between struts of the same form class but of different actual length dimensions. In all cases the data plotted are always referred to the fineness ratio, length of cross-section divided by maximum width of cross-section. Fig. 2 shows the sections, dimensioned as to fineness ratio, that were used in plotting the curves of Fig. 1.

When members are subject to vibration and movement so that they do not at all times present a head-on view to the wind, the effect on the resistance is similar to that experienced in a turn. Interplane wires are particular offenders in this respect.[3] Hence, when streamline wires were adopted, it was not sufficient merely to decide on a shape that offered the least head-on resistance.

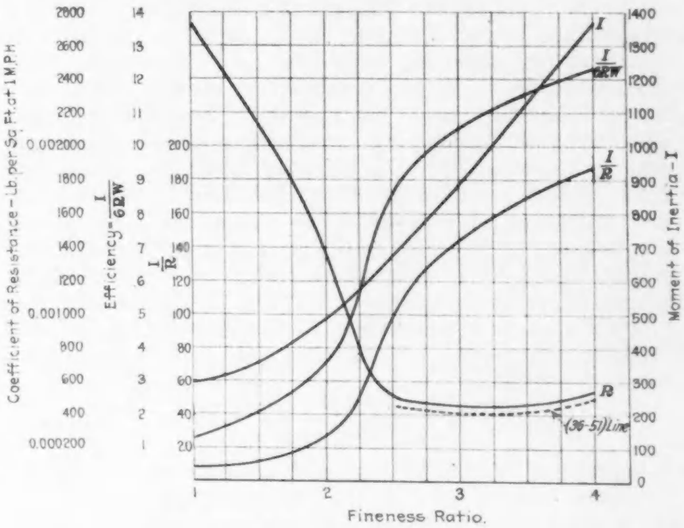


Fig. 1

Experiments with struts showed that for different angles of yaw the resistance of the best shape for head-on wind went up very rapidly with the change in angle. As a result of experiments on different shapes for differing angles, the present generally elliptical shape was adopted. Fig. 3 shows the correction factor for different degrees of yaw.

The general design of the fuselage is frequently fixed by considerations other than those purely aerodynamic. Mounting a flexible gun in the rear cockpit with the average type fuselage, causes a break in the lines of air continuity. The outlines of the engine generally have a marked influence on the cross-sectional and fore and aft disposition of both space and lines. Fighting equipment,

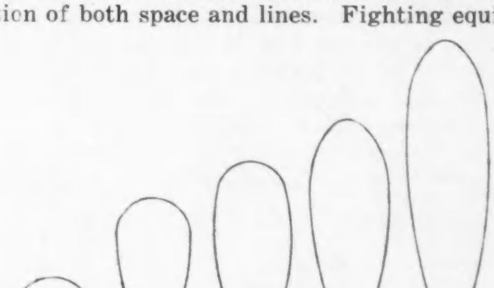


Fig. 2

observation apparatus, the controls, the arrangement of the pilot and crew, these have their individual weight in deciding the shape best suited to the particular conditions. In general, however, discontinuity is avoided as much as possible. The faster the design-speed of the machine, the greater is the consideration given to the "wake" of the larger bodies. Many designs have consequently arisen, varying in their treatment of virtually the same problem, carrying the powerplant and its fuel, the pilot and the crew and the accessory load.

[3]The vibration of round wires has no effect on the air-resistance —see Comparison of the Air Resistance of Vibrating Wires, by T. E. Stanton, in *Aerial Age*, Oct. 18, 1915.

The early forms with open framework are all now replaced with a continuously surfaced structure. Apertures are kept down to the minimum, since theory indicates and experiments show that these add to the total resistance by disturbing the streamline flow. The main distinction in fuselages centers about the differences between the "short type plus tail booms," and the "long continuous type." The Farman and Voisin construction in French planes, the Vickers Gun-Bus and all the FE derivatives, are of the first class. Most of the fuselage construction, however, is of the long continuous type, even when the extended construction merely serves as a boom to the tail, as in the Caproni. The resistance coefficients now available on these various types are meager and disconnected. That is, knowing the coefficient for one form of fuselage does not materially help in determining the resistance of another form. The forms and coefficients given in Table 1 are the results of early and recent tests. The coefficients in the table are all for 1 sq. ft. of cross-section at a velocity of 100 m.p.h., the fuselage inclined 6 deg. to the direction of the wind. The fineness ratio or the maximum length divided by the maximum depth is also noted.

Panels

Extensive experimenting with models and full-scale machines has shown that the factors which for a monoplane form affect a saving are

(1) Wing curve
(2) Aspect ratio
(3) Plane form

For multiplane arrangements the saving is a partial function of the monoplane, with increments due to

(4) Stagger
(5) Gap-chord ratio

The lift-drift, L/D, movement of the center of pressure and cross-section of several well-known wing curves are shown in Figs. 4 and 5. For comparative study the L/D factors for all the sections have been plotted in Fig. 6. The choice of a section depends completely on the service. Thus, if a high-carrying capacity at medium speed is wanted, the curve selected should have an L/D fairly constant over some appreciable range in angle of incidence. If a quick rise is desired at low speed, the lift coefficient at the larger angle of incidence should be high. On the contrary, if a high-speed machine is wanted, but also with a quick get-away, hence fairly low landing and taking-off speed, the L/D factor should be high at both the low and high angles of incidence. Since the weight of the machine is constant, the drift, which is one of the main factors affecting speed, will equal the weight divided by L/D. Hence the larger the L/D ratio, the smaller is the drift, and consequently less horsepower is required to attain or maintain a certain high speed.

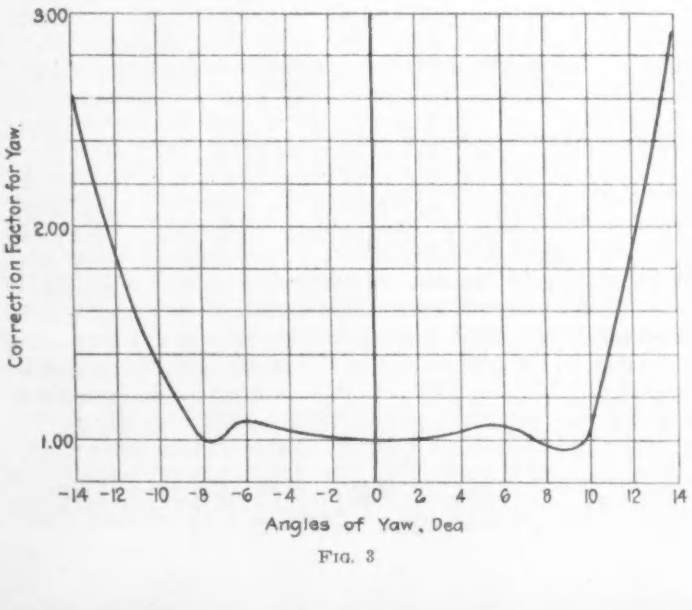


Fig. 3

The more area that can be brought within the province of two-dimensional flow, parallel to the fore-and-aft vertical plane of symmetry, the greater will be the total value of L/D for the entire machine. This is obvious since the end flow of the air at the ends of the panels destroys the lift locally and by creating probable surfaces of discontinuity within the panel region still further increases the drift. Tests have shown that the L/D factor increases with the aspect ratio. However, there are both structural and dynamic considerations which limit the aspect ratio. The average practice of today indicates for ordinary two-place single-engine machines having a velocity of 75 to 90 m.p.h., an aspect ratio of about 7.0 to 7.5; for two-place single-engine machines with a speed of about 125 m.p.h., an aspect ratio of about 6.0 to 7.0; for single-place machines, 100 m.p.h., an aspect ratio of about 6.0 to 6.5; and for single-place machines, 125 m.p.h., an aspect ratio of 5.0 to 5.5.

Table 1—Resistance Coefficients for Different Forms of Fuselage

Fuselage	Length ÷ Depth	Resistance, Lb. per Sq. Ft.	Fuselage	Length ÷ Depth	Resistance, Lb. per Sq. Ft.
FARMAN NO. 1 (NO RADIATOR)	3.2	6.53	F.E. 2B.	4.6	13.88
FARMAN NO. 2 (NO RADIATOR)	3.2	8.56	F.E. 2C	4.6	13.05
FARMAN NO. 3 (NO RADIATOR)	4.3	14.69	F.E. 8	3.1	10.00
DEPERDUSSIN (OPEN MOTOR)	5.3	10.20	DEPERDUSSIN (COVERED MOTOR)	5.2	7.55
S.E. 4 A	4.7	4.92	S.E. 5	5.6	12.85
B.E. 2C	7.2	15.71	B.E. 3	6.2	8.65
AVRO	6.8	11.10	F.E. 7	7.6	5.91
STREAMLINE (ROUND SECTION)	6.4	3.80	STREAMLINE (ROUND SECTION)	6.4	4.93
STREAMLINE (SQUARE SECTION)	6.0	4.08	STREAMLINE (SQUARE SECTION)	6.0	5.35

It is customary to run wind-tunnel tests on panels having an aspect ratio of 6. The Report of the British National Advisory Committee for Aeronautics for 1911-12 published correction factors for different aspect ratios, for individual angles of incidence. Within reasonable percentages these relative factors of correction for each angle of incidence have been found to be constant.

While early airplane builders attempted to follow the

outlines of bird wings, and this still persisted in the early German Taube design, wind-tunnel tests have shown that both stability and good lifting capacity do not always go together for all types of cross-section tested. Eiffel showed by test that a plane form in which the trailing edge extended beyond the leading edge and with the corners slightly rounded presented a better L/D than a rectangular plane form. This gave great impetus to the form here and abroad. Early in the war the Germans used two plane forms in one machine, the modified rectangular in the upper panel and the Bleriot in the lower panel. This was characteristic of several machines. A

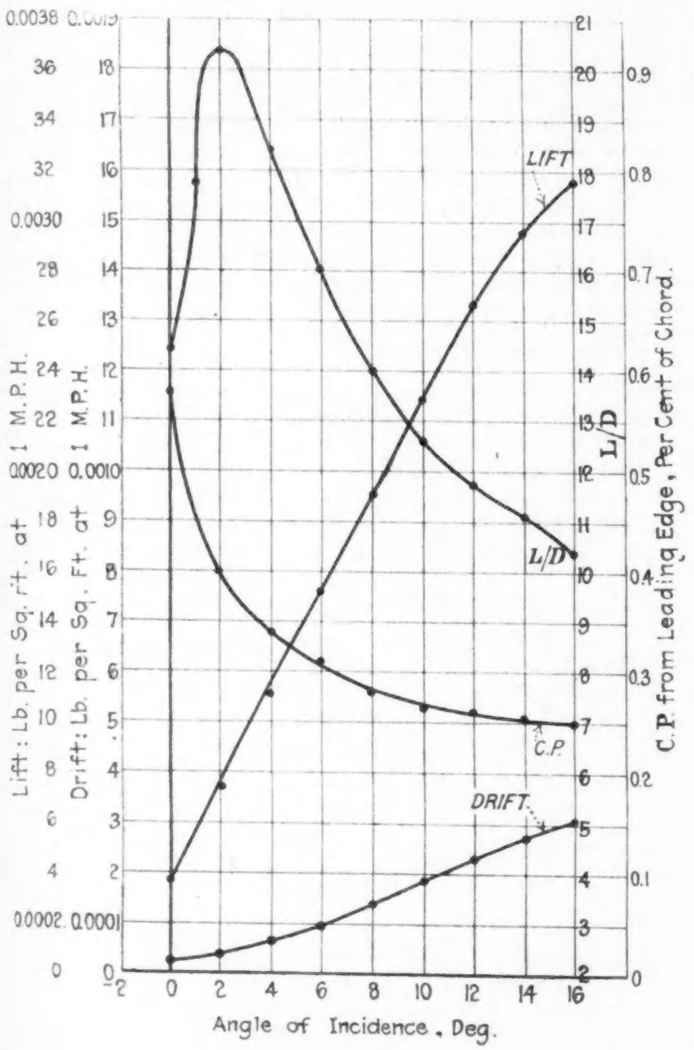


FIG. 4

plane form that early came into prominence with the British was the elliptic-end form. Direct comparative tests on all types of plane forms show that the loading on the complete wing is independent of the form of the tip. While it would appear that for different forms the region of disturbance should vary and hence affect the total loading, undoubtedly the three-dimensional flow masks small regional effects. Tests on a variety of round-ended panels show that a plane form, the end of which is a semi-ellipse, with the major axis normal to the chord and equal to 1.5 times the chord, gives the best results.

Multiplane systems were introduced, after the monoplane was well developed, to provide sufficient supporting area without excessive wing spread and to take advantage of the truss formation, permitting heavier loads to be

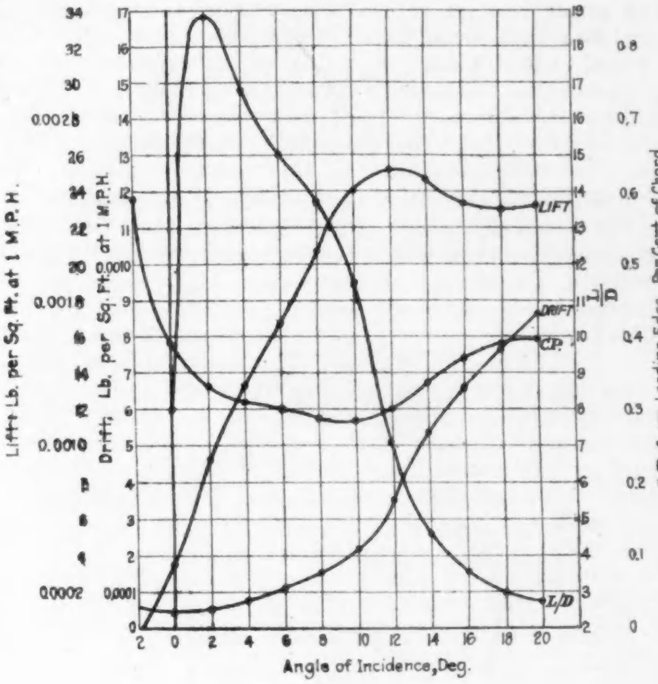


FIG. 5

carried by lighter panel structures. Theoretically a biplane arrangement should show some difference in behavior from a monoplane, for the air flow is confined, with respect to the lower surface of the upper plane and

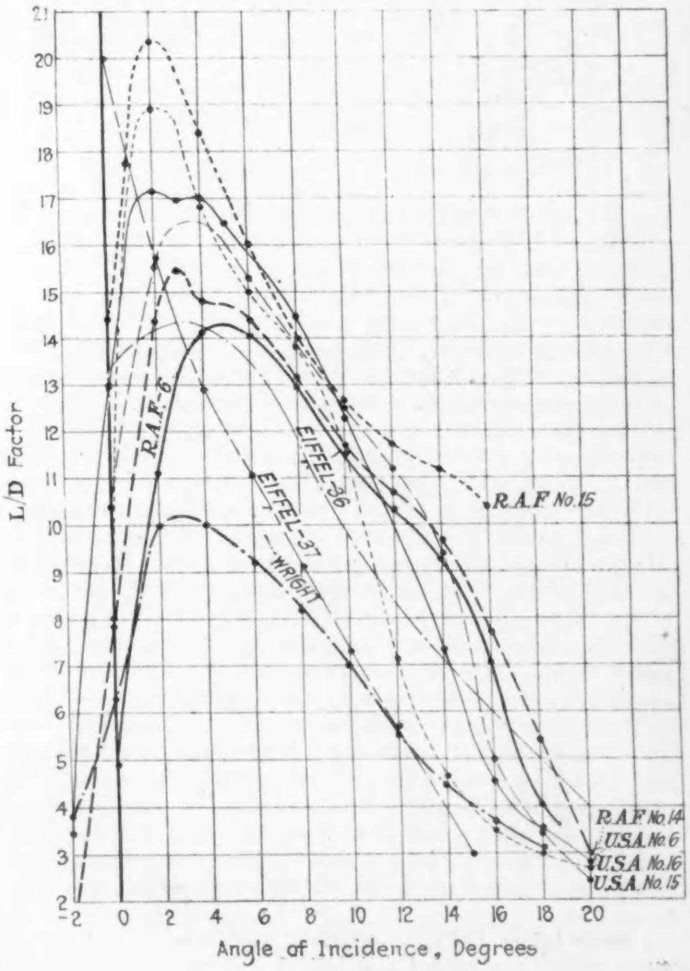


FIG. 6

the upper surface of the lower plane, thus preventing free two-dimensional flow. Experience proves this to be correct. In biplane or multiplane arrangement, it is probable that the air flow between the panels is disturbed and not two-dimensional and that whatever pressure distributions on the individual panels may be set up initially interfere with each other if the regions are close. As the panels are separated horizontally or in the direction of the chord, so that the upper surface of the lower panel is more exposed to free air, theoretical indications based

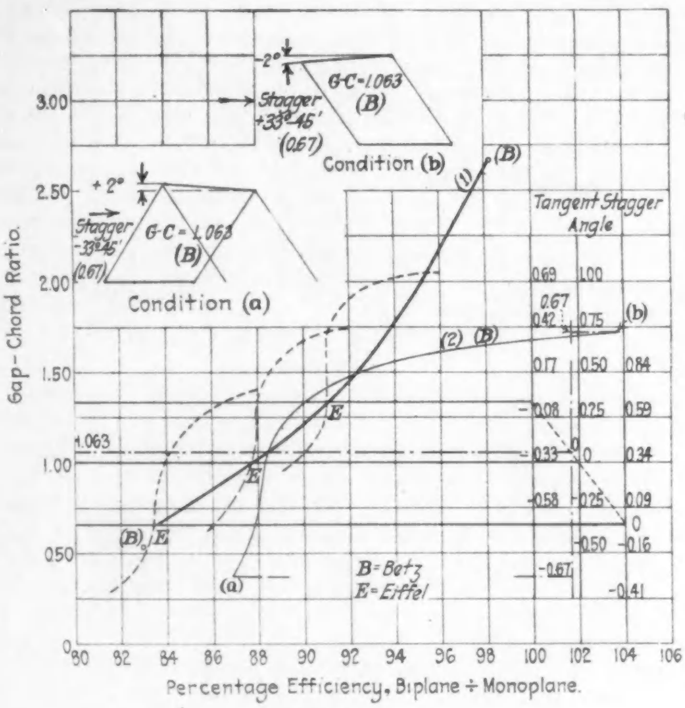


Fig. 7

on the above hypothesis would be for an increase in the lifting effect. Tests have shown that forward staggers increase the efficiency of a biplane arrangement, whereas back staggers decrease the efficiency. This may also be expected from theoretical reasoning. The average order of a biplane efficiency, with respect to a monoplane of the same area, is 82 to 90 per cent, depending on the stagger. The average order of a triplane efficiency is about 77 to 85 per cent. Tests show that about 55 per cent of the biplane load is carried by the upper panel and 45 per cent by the lower, when they are of the same area.

In triplane construction, the arrangement of distribution is roughly 48 per cent upper panel, 21 per cent middle panel and 31 per cent lower panel. Thus it was that in early designs, attempts were made to utilize as much of the more efficient upper panel as was possible without adding too much weight, and the designs showed longer upper panel spans than lower spans. For quick fighting machines today, the overhang has disappeared.

Many experiments with models and tests on full-scale members have been made in an attempt to reach reliable data showing the effect of the interrelated quantities, chord, gap and stagger. M. Eiffel, the National Physical Laboratory, and Göttingen have collected considerable data on models in which these quantities were varied singly, and taken readings for different angles of incidence.

I have taken Eiffel's and Betz' Göttingen results and from them constructed a series of curves, Fig. 7, which gives the efficiency of a biplane in terms of an equivalent monoplane, permitting variation in both gap and stagger. The abscissas are always percentage of efficiency. The coordinates at the left give the gap-chord ratio. At any specific ratio a horizontal line was drawn, upon which was plotted the specific value of the percentage efficiency found by Eiffel or Betz for the condition of "no stagger." The solid curved line (1) thus drawn through these points plotted on the various gap-chord ratio base lines represents the variation in percentage of efficiency with changes in gap-chord ratio when the stagger is not considered, *i.e.*, when the stagger is zero. If an auxiliary coordinate line be erected at the right end of any gap-chord ratio base line previously drawn, and the tangents of the stagger angles be marked off as coordinates, positive and negative with respect to the base line, a new set of reference lines is thus established, based on the main set. The point for zero stagger has been set previously and occurs when line (1) intersects the gap-chord ratio base line. This point is now made the origin for another curve showing the variation in efficiency as the stagger changes, while the gap-chord ratio is held constant. In this manner a series of curves are drawn through curve (1), each showing the variation of efficiency with stagger for a specific gap-chord ratio.

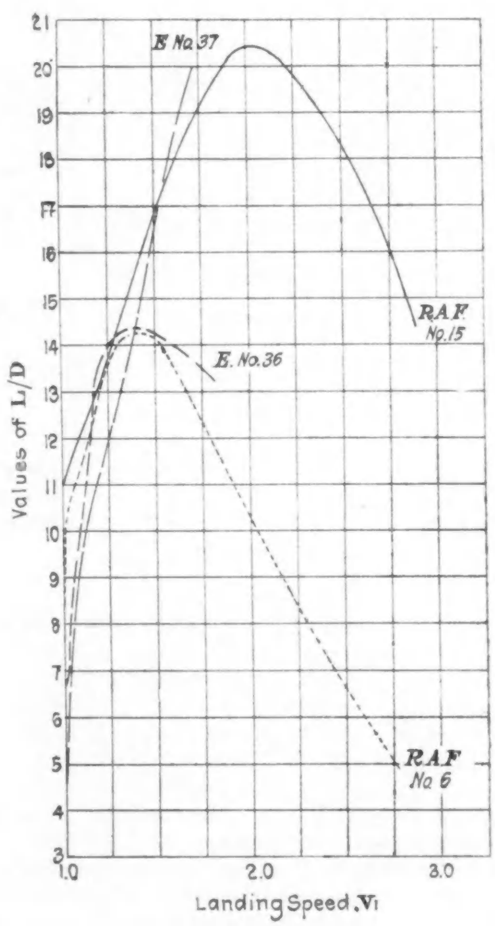


Fig. 8

The three values plotted correspond to 1.33, 1.00 and 0.66 gap-chord ratios. Curve (2) shows the variations found by Betz for a gap-chord ratio of 1.063 when the stagger and angle of incidence were changed from condition (*a*) to condition (*b*).

In general, the values given by these curves are slightly

higher than some of the other tests published, but within the range of ordinary usage the variation will generally be found less than 1 per cent. One point to be noticed is that for a gap-chord ratio of 1.0, no stagger, the efficiency is quoted at 87.7 per cent, whereas recent tests have given the efficiency for these conditions at 84 per cent. Figures on the various properties of triplanes were published by J. C. Hunsaker of the Massachusets Institute of Technology.

Panel Area and Resistance

The total panel area required in any airplane is a function of the airfoil, the weight and the minimum velocity. The maximum speed, however, is a function of the resistance. Therefore every augmentation in lifting capacity for a given area is a conservation of horsepower and increases the efficiency of the machine, since the "resistance area" will be kept constant. If the landing speed be called V_1, we have the relation

$$A = \frac{W}{k_1 V_1^2}$$

giving the area that must be furnished in the panels to sustain flight at the given minimum speed. If the minimum velocity be known, the minimum area will be required at the angle of incidence of greatest value of k, k being the lift coefficient of the airfoil. The maximum speed cannot be predicted until the details of the component parts of the machine are known and the resistance summated. However, assuming that any disturbing moment which would tend to vary the angle of incidence were controlled by the elevators or other means so that the movement of the airplane were horizontal, the velocity at any angle α can be determined by substituting the corresponding value of k_a in the general equation

$$W = k_a A V_a^2$$

in which W and A are already known, and k_a is selected from the "aerodynamic property" of the airfoil with which the machine is equipped. Therefore any required velocity for sustentation at any angle other than the landing angle, provided sufficient power is available to overcome the resistance, may be expressed as

$$V_a = \sqrt{\frac{W}{k_a A}}$$

Substituting the value of A as previously found,

$$V_a = V_1 \sqrt{\frac{k_1}{k_a}}$$

Thus the maximum attainable velocity depends on the sum total resistance of the machine and the available power delivered through the propeller. That airfoil which will sustain the total weight at the given minimum velocity and which will offer the least resistance at the maximum velocity, is therefore the economical one.

From the preceding equation and the aerodynamic coefficients of lift and drift of airfoils, the effectiveness L/D of airfoils at various speeds for any machine of known weight can be compared.

The resistance of the panels at any speed is equal to the total weight of the machine divided by the L/D factor for the angle of incidence that yields the given speed; or

$$R_a = \frac{\text{Weight}}{\left(\frac{L}{D}\right)_a}$$

Since the required horsepower equals $RV/375$, where R is stated in pounds and V in miles per hour,

$$HP_a = \frac{\left[\frac{W}{\left(\frac{L}{D}\right)_a} \times V_1 \sqrt{\frac{k_1}{k_a}}\right]}{375}$$

which may be written $HP_a \sim \left(\frac{D}{L}\right)_a \sqrt{\frac{k_1}{k_a}}$

The horsepower required for any type of wing curve can thus be plotted for various speeds in terms of the landing speed. Fig. 8 shows the relation between the effectiveness (L/D) and various speeds for different types of curves; Fig. 9 shows the relation between the horsepower requirements and various speeds for the same types of wing curves.

A graphic method is thus presented which permits a direct comparison of the performance of several wing curves, both as to lifting capacity and horsepower consumption at various speeds. Fig. 8 shows that for high speeds the R. A. F. No. 15 wing curve has the greatest

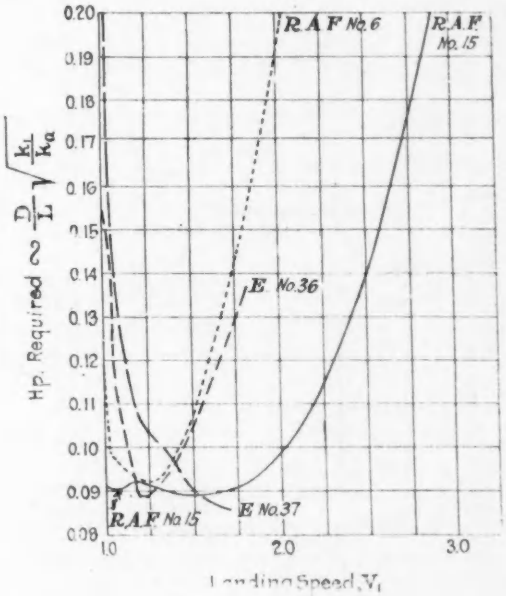


Fig. 9

L/D; hence for any given machine weight, at high speeds, it will offer the least resistance. Fig. 9 shows that for practically all speeds the horsepower consumption of the R. A. F. No. 15 is least. Hence this wing curve is the most economical of the four presented at high speeds. The same superiority is evident at low speeds, hence this wing curve is the best all-around curve.

Fig. 8 shows that for low speeds the L/D values of the R. A. F. No. 6 are greater than for the E No. 36; whereas at the higher speeds the E Nos. 36 and 37 are superior, the R. A. F. No. 15 being excepted.

The curves of Fig. 9 show that for the lower speeds the R. A. F. No. 6 consumes less horsepower than either the E No. 36 or No. 37. The reverse condition obtains at the higher speeds. Hence for heavy machines the high speed of which will not exceed 1.5 times the low or landing speed, the R. A. F. No. 6 curve is preferable to that of either the E No. 36 or No. 37. Of these last two the E No. 36 is better at lower speeds but inferior at higher ones. Unless considerable excess horsepower be available with the E No. 37 at getting-off speed, this curve is uneconomical.

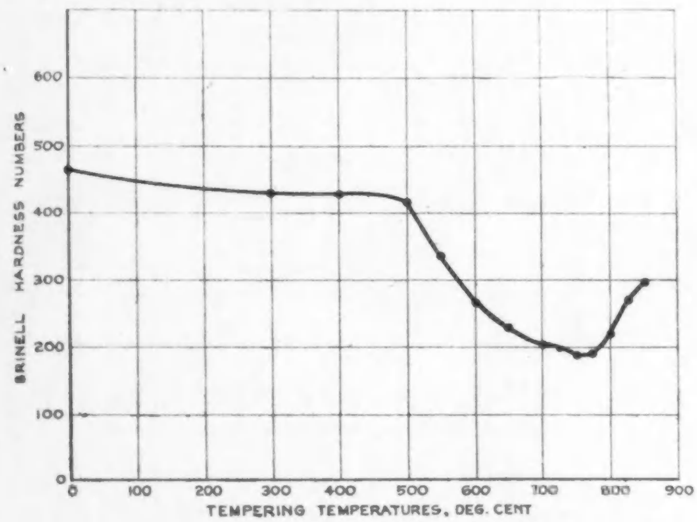
(To be concluded)

High-Chromium Steel for Exhaust Valves

THE Sub-Division which was appointed at the joint meeting of the Iron and Steel Division of the S. A. E. Standards Committee and Sub-Committee X, Committee A-1 of the American Society for Testing Materials, on May 15 has prepared a tentative report covering the properties and uses of the so-called stainless steel containing between 11 and 14 per cent of chromium. Notes on the forging and heat treatment of this type of steel are also given in the report which is printed below.

The Iron and Steel Division of the Standards Committee at a meeting to be held on Sept. 16 will probably consider the advisability of publishing a similar report in the Notes and Instructions of the S. A. E. Steel Specifications. The report substantially as prepared follows:

High-chromium or what is commonly termed stainless steel,



RELATION BETWEEN THE TEMPERING TEMPERATURES AND THE BRINELL HARDNESS NUMBERS OF A HIGH-CHRONIUM STEEL

which was originally developed for cutlery, has in the past 2 of 3 yr. been used considerably for exhaust valves, particularly in aircraft engines, because of its resistance to oxidation or scaling at high temperatures.

Composition

Carbon	0.200 to 0.400
Manganese	not over 0.500
Phosphorus	not over 0.035
Sulphur	not over 0.035
Chromium	11.500 to 14.000
Silicon	not over 0.300

Forging The steel should be brought up to heat slowly and forged at a temperature above 1750 deg. fahr., preferably between 1800 and 2200 deg. fahr. If forged at temperatures between 1650 and 1750 deg. fahr., there is considerable danger of rupturing the steel due to its hardness at red heat. Owing to the air-hardening property of the steel, the flash on drop forgings should be trimmed off while hot. Thin forgings should be reheated to redness before trimming off the flash as otherwise they are likely to crack.

Heat Treatment Forgings will be hard if they are allowed to cool in air. This hardness varies over a range of from 250 to 500 Brinell, depending on the original forging temperature.

Annealing This can be done by heating to temperatures ranging from 1290 to 1380 deg. fahr., and cooling in air or quenching in water or oil. After this treatment the steels will have a hardness of about 200 Brinell and a tensile strength of 100,000 to 112,000 lb. per sq. in. If a softer anneal is desired the steel can be heated to a temperature of from 1560 to 1650 deg. fahr. and cooled very slowly. While softer the steel will not machine as smoothly as when annealed at the lower temperature.

Hardening This steel can be hardened by cooling in still air or quenching in oil or water from a temperature between 1650 and 1750 deg. fahr.

Physical Properties The physical properties do not vary greatly when the carbon is within the range of composition given above, or when the steel is hardened and tempered in air or hardened and tempered in oil or water.

Valves These have generally been made to the following specification of physical properties:

Yield point, lb. per sq. in.	70,000
Tensile strength, per sq. in.	90,000
Elongation in 2 in., per cent.	18
Reduction of area, per cent.	50

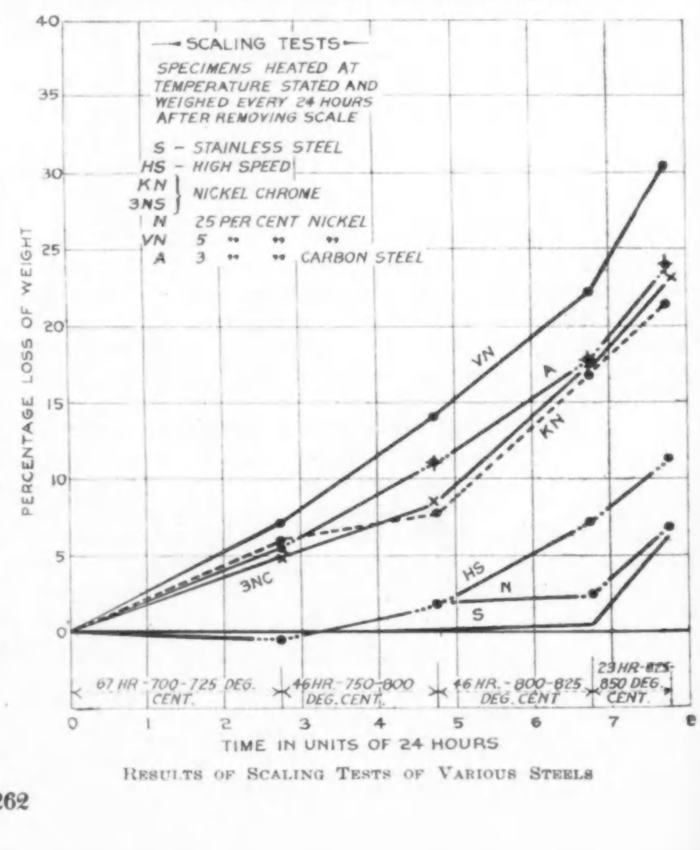
The general heat treatment is to quench in oil from 1650 deg. fahr. and temper or draw at 1100 to 1200 deg. fahr. One valve manufacturer stated that he hardens valves of this steel by heating the previously annealed valves to 1650 deg. fahr. and cooling in still air. This treatment gives a scleroscope hardness of about 50.

Cold-Working This steel can be drawn into wire, rolled into sheets and strips and drawn into weldless tubes.

Corrosion This steel, like any other steel when distorted by cold work, is more sensitive to corrosion and will rust. Rough cut surfaces will rust. Surfaces finished with fine cut are less liable to rust. Ground and polished surfaces are practically immune to rust.

Scaling Comparative resistance to scaling or oxidation at high temperatures is shown in the accompanying chart.

Applications In addition to use in valves this steel should prove very satisfactory for shafting, water-pumps and other automobile parts subject to objectionable corrosion.



RESULTS OF SCALING TESTS OF VARIOUS STEELS

	C.... 0.20 Mn.. 0.45 Cr...12.56	C.... 0.27 Mn.. 0.50 Cr...12.24	C.... 0.50 Cr...14.84
Quenched in oil from deg. fahr.	1,600	1,600	1,650
Tempered at deg. fahr.	1,160	1,080	1,100
Yield point, lb. per sq. in.	78,300	75,000	91,616
Tensile strength, lb. per sq. in.	104,600	104,250	123,648
Elongation in 2 in., per cent.	25.0	23.5	14.5
Reduction of area, per cent.	52.5	51.4	33.5

COMPARISON OF PHYSICAL PROPERTIES BETWEEN AIR, OIL AND WATER HARDENED STEEL HAVING CHEMICAL ANALYSIS

Carbon	0.240
Manganese	0.300
Phosphorus	0.035
Sulphur	0.035
Chromium	12.850
Silicon	0.200

Hardening Medium	Hardened from Deg. Fahr.	Tempered at Deg. Fahr.	Elastic Limit, Lb. per Sq. In.	Tensile Strength, Lb. per Sq. In.	Elongation in 2 In., Per Cent	Reduction of Area, Per Cent
Air	1,650	930	158,815	192,415	13.0	40.5
		1,100	99,680	120,065	21.0	59.2
		1,300	70,725	101,250	26.0	61.6
		1,380	66,080	98,335	28.0	63.6
		1,470	70,785	96,990	27.0	64.7
Oil	1,650	930	163,070	202,720	8.0	18.2
		1,100	88,255	116,480	20.0	56.9
		1,300	77,950	105,505	25.5	63.8
		1,380	88,255	98,785	27.0	66.3
Water	1,650	930	158,815	202,050	12.0	34.2
		1,100	90,270	120,735	22.0	59.8
		1,300	66,080	102,590	25.8	64.8
		1,380	67,200	97,890	27.0	65.2

RESULT OF LETTER BALLOT ON STANDARDS

AT the Summer Meeting of the Society held June 23, thirty-three recommendations of various Divisions of the Standards Committee were approved for final presentation to the voting members of the Society. These were adopted in their entirety by the letter ballot, which closed on Aug. 22. The reports on which this action was taken were printed in THE JOURNAL in the August issue, on pages 176 to 187 inclusive.

The complete vote on the recommendations is given below.

	Yes	No	Not Voting	Blanks
REPORT OF ELECTRICAL EQUIPMENT DIVISION				
Rating of Storage Batteries, Electric Lighting Plants	140	2	94	20
Cable Terminals for Generators, Switches and Meters	149	1	88	18
Barrel Mounting for Starting Motors	153	0	84	19
REPORT OF IRON AND STEEL DIVISION				
Screw Stock	166	0	62	28
Chromium Steels	163	1	67	25
Nickel-Chromium Steels	164	0	67	25
Tungsten Steels	162	0	70	24
REPORT OF LIGHTING DIVISION				
Bases, Sockets, Connectors	140	0	90	26
Focusing Lengths of Incandescent Lamps	155	0	98	23
Lens Sizes	133	0	99	24
REPORT OF MISCELLANEOUS DIVISION				
Flexible Metal Tubing	146	1	77	32
Hub Odometers for Trucks	108	0	112	36
Steering-Wheel Hubs	129	0	92	35
REPORT OF MOTORCYCLE DIVISION				
Spark-Plug Shells	106	1	122	27
Headlamp Mounting Lugs and Supporting Prongs	83	0	138	35
Motorcycle Chains	83	0	139	34
Approval of Existing S. A. E. Standards	110	1	112	33
REPORT OF STATIONARY ENGINE AND LIGHTING PLANT DIVISION				
Ratings of Storage Batteries, Electric Lighting Plants (in confirmation of Electrical Equipment Division Report)	99	3	94	60
Voltage and Capacity Ratings, Electric Lighting Plants	121	2	112	21
S. A. E. Engine Testing Forms	131	0	98	27
Round Pipe Flanges	113	2	107	34
REPORT OF TIRE AND RIM DIVISION				
Solid Tire Sizes	128	1	96	31
Carrying Capacity of Solid Tires	123	2	100	31
Solid Tires for Single and Dual Wheels	122	2	101	31
Base Bands for Solid Tires	119	2	104	31
Solid Tire and Wheel Diameters, Wheel Circumferences	122	1	101	31
Solid Tire Sections	119	0	104	33
Section Dimensions of Single and Dual Solid Tire Wheels	123	1	99	33
Pneumatic Tires and Rims for Passenger Cars and Commercial Vehicles	125	2	82	27
Wood Felloe Dimensions for Pneumatic Tire Rims	138	0	87	31
Carrying Capacities and Inflation Pressures of Automobile Pneumatic Tires	145	1	86	30
REPORT OF TRANSMISSION DIVISION				
Tire-Pump Mounting—Transmission	144	2	81	29
REPORT OF TRACTOR DIVISION				
Rims, Cleats and Lugs for Tractor Wheels	89	2	129	36
REPORT OF TRUCK STANDARDS DIVISION				
Power Take-Off	106	4	113	33

Valid ballots counted, 256
Invalid ballots received, 1
Unsigned ballots received, 5
Ballots received after count, 8
Number of subjects adopted, 33
Number of subjects rejected, 0

QUESTIONS ASKED BY TRACTOR PROSPECTS

WITH a view to securing information which would answer questions most frequently asked by farmers who are considering the purchase of a tractor, an investigation among tractor owners was made in Minnesota by the office of farm management, Department of Agriculture, cooperating with the State agricultural organizations. The results were recently made public. Since the territory covered is typical to a large extent of diversified farming, the results secured will apply to a large number of other agricultural sections. From the standpoint of the tractor manufacturer and dealer, special significance attaches to these results, which point out what the farmer expects of a tractor and the conditions that must be met before he decides to purchase one.

"Can I run a tractor?" This is one of the first questions asked by a prospective purchaser. Tractor owners answered in response to this inquiry that almost any farmer can run a tractor successfully if he will secure proper instruction. Of course, the best results are obtained after the operator has acquired experience, as was shown in the case of two neighboring farmers. One was well acquainted with the tractor before purchasing one for his farm, while the other did not understand its principles. As a result the inexperienced operator had almost worn out his outfit at the end of 4 yr. and therefore had a high depreciation cost, which ran his plowing cost per acre up to $2.69 as compared with $1.49 for the experienced operator. If definite instruction is secured at the beginning, experience may be secured at much less expense.

Another question is: "Can I farm more land with a tractor?" Among 149 farmers reporting, 44 increased their farm area an average of 105 acres, and farmed with two horses less after purchasing tractors. The remainder did not increase their acreage but farmed with fewer horses, two being displaced per farm. The average increase per acre on all farms using a tractor with capacity to pull three 14-in. plow bottoms was 39 acres, compared with an average of 7 acres increase where a two 14-in. bottom outfit was used and 32 acres where a four 14-in. bottom outfit was used. Obviously, the larger outfits were more capable of taking care of an increase in acreage. Large-size fields relatively reduced the amount of time required in turning a tractor at the ends and in this respect the longer the fields are the better. Sloughs, potholes, stumps and stones were found to delay tractor work.

Reduction in Cost and Animals

Practically every farmer considering the purchase of a tractor asks whether a tractor will make it possible to keep fewer horses. Answers to this question indicated that this depended on the kind of crops grown. In sections where small grains were the main crops, the number of horses displaced depended upon how much of the seeding, disking and harvesting the tractor could take over in addition to plowing, because these operations required nearly as many horses as plowing. In the corn growing sections, horses needed for cultivating prevented the tractor from displacing as many work animals as it would have displaced otherwise. On the average, two horses were displaced per farm, but a saving was made on the feed for the horses kept, since it was possible to cut the grain ration almost in half during the plowing season when the horses were not at work.

Those farmers who were most proficient in handling the tractor were able to dispense with a larger number of horses, because they did not keep horses to fall back on in case anything went wrong with the tractor. It may reasonably be expected that the more experienced a tractor operator becomes the more able he will be to eliminate horses on his farm.

One of the most important problems for the farmer while labor is high priced is how to save hired help. In this connection tractor owners reported the saving was greatest when the outfit was used for other work in addition to plowing. The accompanying table gives the hourly cost of depreciation, labor, fuel and oil, interest and repairs for different classes of plow together with the plowing cost per acre.

Number of Plows	Selling Price	Hourly Cost of Depreciation, Etc.	Plowing Cost per Acre	Rate of Plowing, Acres per Hr.
2	$900	$0.94	$1.58	0.6
3	1,450	1.24	1.55	0.8
4	1,950	1.52	1.52	1.0
6	2,600	2.13	1.63	1.3

If the tractor is used more than 500 hr. per yr., the items of interest on investment and depreciation will be less per hour, which would also reduce the cost per acre of plowing. This again suggests that the most economical use of the tractor requires that it be used for as much work as possible during the year.

Securing Instruction

Replies to the question of how one could learn to run a tractor showed that several ways were open to the average farmer. Undoubtedly the best suggestion was to handle the tractor in the field under the direction of an experienced operator. This work of course should be supplemented with some study of the principles of the internal-combustion engine. Another suggestion was to attend one of the tractor schools that are now being conducted in different parts of the country by tractor companies and agricultural schools. The courses vary in length from 1 week to about 3 months and include considerable practical work on the machines.

Perhaps the ideal way would be to combine work in the field with a course of instruction at some school. When this is not practicable much can be learned by consulting some of the more successful tractor operators in the community and studying the instruction books sent out by the manufacturers. Instructions should be consulted frequently when making adjustments or when something goes wrong with the machine. Although general books on tractors furnish valuable information they are not as satisfactory as a specific instruction book dealing with the tractor which has been purchased.

Starting a New Tractor

Tractor owners agree that care should be taken in starting up a new tractor. Too much care cannot be used during the first 2 or 3 days, according to experienced operators, because neglect at this time may cause considerable expense and delay. During the first runs, examination should be made of the oiling and cooling systems, leaky connections should be fixed and readjustment should be made of bearings which tend to heat up. In new tractors all nuts and bolts must be kept tight because they are more likely to work loose at this time than later. It may be necessary to clean the fuel pipes after the first few hours' running because a new machine usually has more or less dirt in the fuel tanks and passages. The oil system also may become clogged from small particles of metal left in the crankcase when the engine was assembled. These particles gather around the oil screen at the inlet to the oil-pump or work into the cylinder. Therefore it is advisable to change the oil in a new engine which has been run a few hours.

The investigation brought out the fact that the life and service of a tractor are largely dependent on the care which the machine receives both when in use and when idle. Time spent in studying the machine is well spent, because success with the tractor depends as much upon the operator as upon the machine and perhaps more.—*Farm Implement News.*

Tractor Engines and Fuel Limitations

By H. L. Horning [1] (*Member*)

Detroit Section Paper

Illustrated with Photographs and Chart

IT would be impossible to treat the subject of tractor engines in its entirety in one paper. Further than pointing out the general tendency of design this paper will consider tractor engines entirely from the standpoint of fuel and its limitations.

Four-cylinder tractor engines seem to be rapidly becoming standard. With a slight increase in the use of overhead valves the L-head cylinder is the most popular and no doubt will be for some time, due to its simplicity and the familiarity of most farmers with this form of engine. Ford, Overland, Maxwell, Studebaker and Dodge cars are in the great majority on the farms. This familiarity with their construction and use is the controlling factor in upkeep of tractor engines. No quantity production has yet been obtained or is likely to get far for some time to come with anything but the commonest form of cylinder and other features. This judgment is based entirely on the limitations in upkeep knowledge of the average user.

There are some who no doubt will differ with this conclusion from an engineering standpoint, but this effort would be lost if it failed to impress the fact that tractors are not built for nor operated by engineers, and that many elements of design in a tractor for use in the next 5 yr. must be determined from an economic viewpoint. Besides this factor it can be shown that with the knowledge we now have approximately the same result in power and economy can be got with an L-head as with a valve-in-the-head engine for truck and tractor use, within the limits of 90 lb. mean effective pressure and a fuel consumption of 0.62 lb. per hp.-hr. and at speeds unde 1000 r.p.m.

Tractor Forms

Tractors vary considerably in form and design. Tractor design and tendencies seem to arrange themselves in fours. There are four general types of tractor, as follows:

(1) Automobile type, of which the Fordson, G. M. C., Heider and R. & P. are representative

(2) Cross-engine type of which the Huber, Parrett and Case are representative

(3) Special purpose type of which the Holt, Best, Cleveland, Trundaar, Yuba and Bullock are types of the caterpillar form, while the La Crosse and Bates Mule together with other unique forms are particularly designed for certain service.

(4) Farmer type such as the Gray, Nilson, many of the International, Avery and E.-B. models, is built on the basis of long field experience and gives general satisfaction

The engine is a vertical L-head four-cylinder type, the transmission has four speeds, three forward and one reverse, and there are four wheels.

It is unnecessary to go into engine design as there are many engines giving fair success. It has been thought advisable to deal at length with the list of troubles with engines which have been found to demand the greatest amount of attention of the farmer.

The list below is taken from an investigation by the Department of Agriculture, in which from 2179 reports the following list of troubles on the engine was compiled:

TRACTOR ENGINE TROUBLES

Magnetos	299
Spark-plugs	110
Carbureters	104
Bearings	80
Cylinders and piston-rings	61
Valves and springs	43
Lubrication	29
Starting	28

We will now proceed to consider each of the above from a broad standpoint, and to point out particularly the relation of fuel to these difficulties.

Magnetos

There is no doubt that magnetos have troubles all their own intimately related to the electrical problems of ignition and the demand of tractor service in which this beautifully made device is expected to stand out all winter or through April showers and function immediately on demand of the careless owner. With fuels of today it is difficult to ignite present mixtures due to their weight and to defects in carburetion. A number of tests show that with the present system of carburetion as much as 20 per cent of the fuel fails to contribute to the power output. This loss affects the results through a rapid coating of spark-plugs with the carbon of incomplete combustion. Magnetos do not benefit any more than the engines generally from carbon coating and short-circuiting of the plug. Reports of service men indicate that magnetos are often blamed for conditions arising from carbon deposits in the cylinders.

Spark-plugs

Closely related to magneto difficulties are those in which the spark-plug is involved. Volumes could be written on this subject, but when we realize that upward of 100,000,000 spark-plugs are sold annually we get some idea of the difficulties which engine construction and its inferior capacity for burning our present day fuels with the Otto cycle impose on the spark-plug manufacturer. Generally speaking, a spark-plug in a tractor engine is seldom exposed to the temperature stresses of an aviation engine, and yet one of the controlling factors of power production in tractor engines is the pre-ignition of the mixture due to high spark-plug temperatures. This of course applies to the electrodes which attain high temperatures. Present fuels containing heavier oils having end-points from 367 deg. fahr. upward break down easily. Good designing may largely eliminate pre-ignition but fuel limitations cause many of the objectionable spark-plug difficulties discussed under the heading of detonation. While the tractor spark-plug with poor designing of cylinders with respect to water circulation is prone to cause pre-ignition, yet many plugs run too cool, which does not allow the inevitable carbon deposits to burn and in fact favors the formation of carbon very much. One of the most important ele-

[1] General manager and secretary, Waukesha Motor Co., Waukesha, Wis.

ments of the design in a tractor engine is the location of the spark-plug. The general considerations are as follows:

(1) The plug should be located as near as possible to the center of gravity of the mixture in the combustion chamber when the mixture is about to fire
(2) It should be so located as to be out of the exhaust gas stream
(3) It should be located so as to get the blast of this incoming rich mixture, or in such a place as will insure that the mixing surrounding this electrode will be highly explosive and not deadened by a residual charge
(4) The cooling water stream which has picked up a large volume of heat from the exhaust valve environment usually insures temperature enough to keep a good clean plug and a cooling effect that will keep pre-ignition out of the probabilities
(5) No cylinder-head should be designed which will demand a long spark-plug to reach the mixture
(6) A vertical spark-plug is the only type which runs a long time without cleaning. The necessity of putting spark-plugs at an angle if not horizontal in the head of a valve-in-head engine is one of the inherent defects of that type of engine. This is due to a cleaner oil drainage from the plug vertically placed
(7) The plug should not be placed so as to get the direct sweep of gases passing by the piston and rings on the suction stroke

The above considerations are particularly for the guidance of the engine designer. Beyond this he should keep in mind that the engine must work irrespective of where the farmer buys his plugs or their design.

Should the user desire advice as to the type of plug it is only necessary to observe the following points:

(1) The insulator should be of the best grade of porcelain or stone now available
(2) The center electrode should be at least 3/32 in. in diameter, well smoothed off, rounded and the distance of its tip from the outside air a minimum. Cooling ribs are very desirable. No sharp corners or points should be presented to the combustion chamber
(3) It is not easy to give general specifications for a good mica plug although there are many. As a class they are to be avoided

Aside from temperature problems the greatest difficulties with spark-plugs arise out of the limitations of the fuel, resulting in a deposit of carbon. Excessive lubrication in the combustion chamber can result from heavy fuel and further favors the short-circuiting of the plug with oil and carbon.

Carbureters

Whatever the shortcomings of carburetors, there is no doubt that they must stand some real maltreatment for any and all trouble symptoms on the truck and tractor. The continual fussing with the carbureter in and out of adjustment is responsible for the wide range of mixtures and results obtained.

The gradual increase in the boiling temperature of the heaviest oil in the fuel is presenting a hard problem to the engineer and is also the cause of frequent and sometimes unnecessary adjustment of carbureters. Fuels differ widely, running from the light and easily vaporized that are within the range of modern gasoline carbureters and vaporizers to far beyond what can be handled. As a matter of fact it is easily demonstrated that the average engine actually returns useful power from only 80 per cent of the fuel. Whatever may be the normal losses to the radiator, exhaust, friction horsepower, radiation, etc., in a modern engine burning a perfect mixture, one-fifth of modern gasoline with an end-point of 450 deg. is beyond hope of burning with engines, vaporizers and carbureters as now constructed. We have demonstrated that it is commercially possible to increase mileage 50 per cent in many cases where vaporization is merely substituted for metering and mixing.

The name carbureter became a misnomer when the end-point of gasoline exceeded 300 deg. fahr. Present fuel specifications call for 50 per cent of fuel to come off under 302 deg. fahr. All above 60 per cent presents a serious problem in vaporization.

Carbureters as commonly made today consist of four valves, using the term valves in the broadest sense as a means of controlling flow. These are:

(1) A needle-float valve for maintaining a constant level of fuel with respect to the fuel-valve
(2) A fuel-valve or valves supplying the fuel in definite quantities
(3) An air-valve or passage supplying air in response to the engine demands and in most systems regulating the fuel flow
(4) A heat valve broadly speaking for the purpose of supplying a sufficient quantity of heat to vaporize that proportion of the fuel which lies beyond the 302-deg. fahr. point and which is not properly vaporized by the common carbureter and intake pipe passages

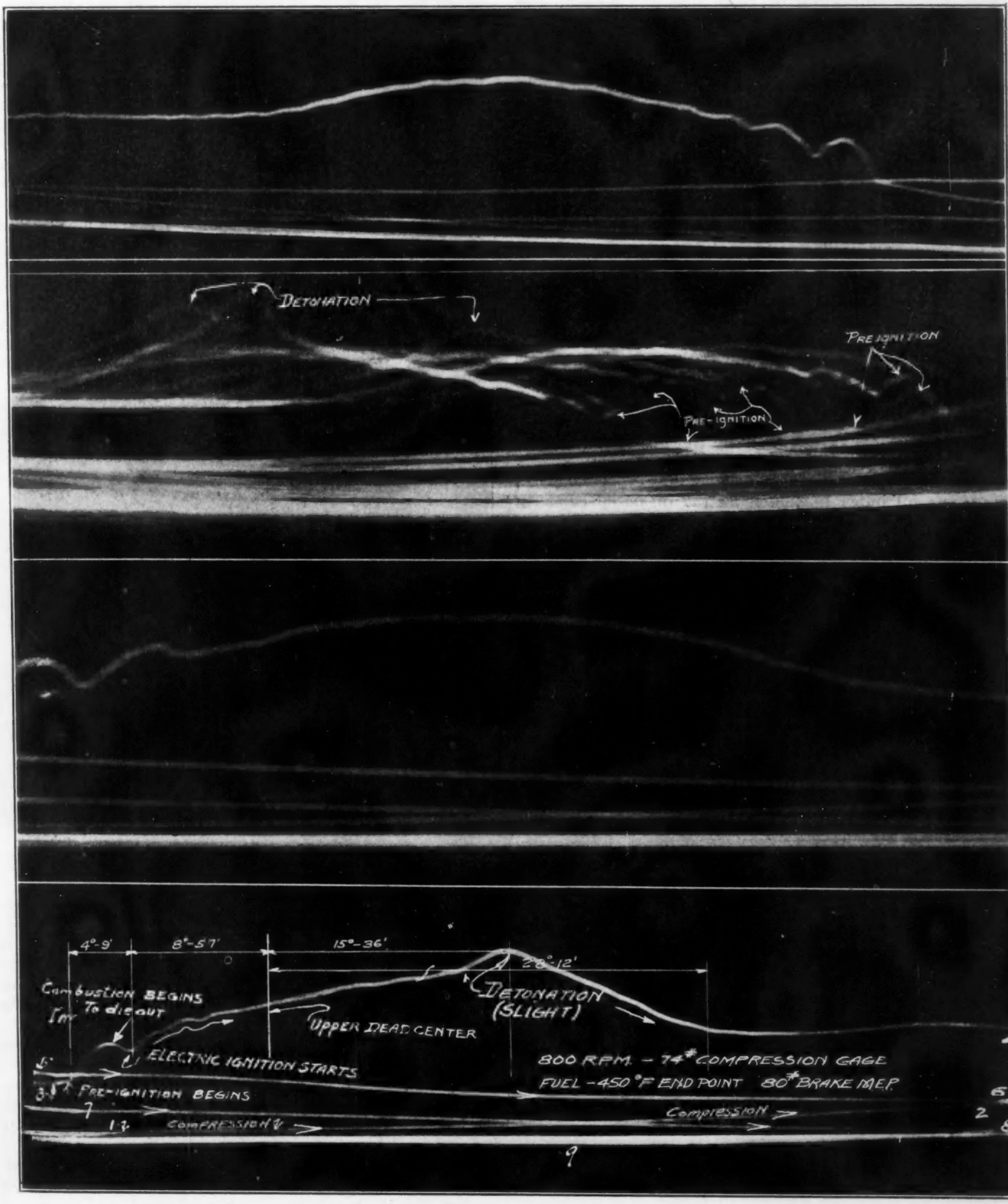
Modern carbureters are either devoid of the heat valves or have only rudimentary and inadequate means of thoroughly vaporizing the fuel. Herein lies the hope of our immediate future, and no firm will be successful that cannot supply adequate heat control. By far the greatest number of our engine difficulties from fuel characteristics arise out of the simple necessity for a properly vaporized fuel.

The heat may be supplied in many ways. The valve referred to can consist of a thin membrane to conduct the heat of water or the exhaust. It can be a thick ribbed section. It can utilize ingenious heating of the air or fuel or both, or a combination of many heating devices, but whatever it is, the fuel must be vaporized and the operator and device must control the flow of heat to the fuel.

Manograph charts of common designs indicate a vast change in mixture composition from one explosion to the other. One explosion varies from another as night from day. Pre-ignition, rapidity of initial ignition stages, variable explosion lines, detonation, multiple combustion, incipient combustion, late temperatures and pressures, all alternate with good combustion effects.

One investigator has shown in working out a temperature control that a change of 8 deg. fahr. in the neighborhood of the correct temperature, which I am not at liberty to give you, makes a difference of 20 per cent in economy. The Bureau of Standards, working with a highly ingenious device for measuring flame propagation in the cylinders of a Liberty engine, found that flame propagation varied from one explosion to another in the order of 100 to 700 per cent. Beyond these citations much practical evidence points to the fact that the fundamental defect of our present practice is lack of vaporization, hence heat control.

The above remarks are based on burning the indefinite fuels known as gasoline. In the attempt to burn kerosene the art of vaporizing is still in the undeveloped state and it can be said we fail in handling kerosene for the



Manograph Charts Showing Variations in the Composition of the Air-Fuel Mixture for Different Explosions

same lack of a better understanding as to how to prepare the mixture for combustion. No mention has been made of the limitation of fuels due to chemical compounds of such instability that they will not stand the destructive effect of heat and pressure developed in the first stages of combustion. The causes of considerable deposits of carbon in the cylinder and the gas knock known as "ping," "pink," pre-ignition, etc., generally most noticeable at the bottom of a hill or following the sudden use of accelerator or when a so-called overload is applied and particularly noticeable at the speed of maximum torque are in fuel composition. This will be dealt with under the heading of fuel, but is mentioned here as one of the limitations of fuels which can be materially reduced by proper vaporization methods.

Tractor Bearings

Nothing can take the place of design and good workmanship in bearings, nor can lubricating oil be expected to cover the defects of a bad system of lubrication. The most common type of lubrication is the splash system in which the level is established by overflow dams. Another form and the most reliable one is the splash system in which the oil level in deep troughs is maintained correctly within a wide range by a set of the oil scoops on the connecting-rod. The oil-pump capacity in pumping the oil into the troughs is just equal to that of the scoops to throw the oil out. Inasmuch as the oil-pump capacity varies as the speed of the engine and the rod scoop capacity varies as the speed, the level of the oil is always assured and constant. Force feed through a hollow crankshaft is a well-known and high-class system. It has not been widely adopted because of the difficulties with the leakage of oil under pressure both past the piston and rings and at the crankshaft and because of the unusual workmanship required for maintaining the pressure. In both systems old oil is pumped over and over and this leads to the bearing troubles with tractor engines.

Lubricating oil is little understood even by the refiners. Most tractor oil is so loaded with the heavier portions that with high pressure and temperature under the piston-heads and walls it breaks down into lighter oils, carbon and tars. Added to this, many engines suffer from dirt, dust and sand which enter either at the carbureter or breather. Taken altogether the oil in the crankcase of an engine in use for a month with either the splash or common force-feed system is usually a bad mixture and entirely unfit for lubrication. With a force-feed type unusual care must be taken to strain and settle all grit or dirt out of the oil or it will cause unusual damage to the journals and bearings. No such care is necessary with the splash system as it seems to develop the least difficulty with dirty oils. With a well-filtered clean oil of good body, the force-feed system works exceedingly well so long as the bearings are in good adjustment. A surplus of oil must be available at all times in order that one or more bearings in a loose condition will not starve the others. Unusually good piston and cylinder fit must prevent over-oiling of the cylinders when the rod bearings are loose.

The ideal system, if expense and care are no object, is the force feed of fresh oil to the crankshaft bearings and the cylinder in exact quantities. So far as results are concerned on the surfaces of the bearings lubricated, this method is not only the most economical in oil consumed but also insures the longest life to both the journals and the bearing surfaces.

This brings us to the effect of heavy fuel on the bearings of tractor engines. Incomplete vaporization leaves heavy fuel unburned, incompletely burned and decomposed on the walls of the cylinder and the combustion chamber. Under the action of high heat the fluid residue flows down the cylinder, past the rings and through the oil drain holes so commonly used into the crankcase.

The products of complete and incomplete combustion found in crankcase oil range in hydrocarbons from formaldehyde to sugars. They include acetone, alcohols, sorghums, formic acid and a list of disinfectants varying in composition according to the circumstances of combustion. This mixture taken together with the solid contents mentioned above constitute about the worst lubricant a cylinder and bearings could have. The lower crankcase is the catch basin for the by-products of the imperfect combustion process. It is the main sewer for decomposing body fillers of our poorly compounded lubricating oils. It is the settling basin for steel, iron and bearing particles which slough off into the lubricants, and the crankcase with its oil-pan forms the dust pan of the self-appointed air cleaner which duty every engine takes upon

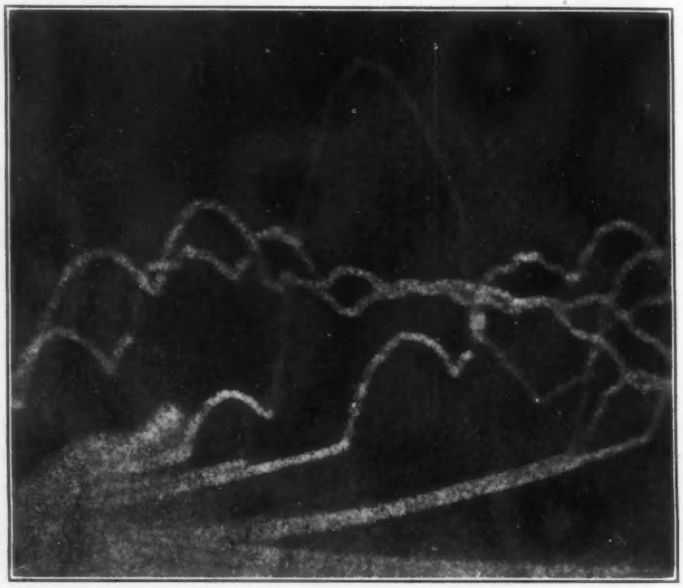


Chart Showing the Heat and Pressure Developed in the First Stages of Combustion

itself. Taken from an unbiased standpoint have not engineers in the tractor engines of today finally arrived at about the worst lubricating conditions possible, and is there any way by which we could get more fuel with the lubricant than by our present design of oil-scraper pistons? The man was a keen observer who said: "Tractor engines work in spite of the designers and users."

There seem to be some very bad effects on the steel journals and the bearing materials due to the heavy fuel and by-products of combustion. In England some practical men and engineers as well, consider an engine "done for" if it is once thoroughly saturated with some of the fuel compositions.

In the question of bearings again, the method of lubricant distribution and economic factors impose the splash system in its most thoroughly worked out form as a good standby under all circumstances. Most men understand it best, or, to be frank, pay least attention to it. As an all-around system it takes care of itself better than any other. The ideal system of fresh oil to all points is perfect, theoretically, but the complications and details together with thickening of the oil in cold weather make

it hard to introduce. The force feed through the crankshaft will become widely used when the manufacturer and users know more about it.

Bearings suffer under heavy fuel conditions due to the high pressure of detonation and pre-ignition. The latter can be controlled by design, as will be mentioned shortly. Both pre-ignition and detonation are the limiting factors of our modern fuels. It is not possible to state which of the two evils is the most detrimental to a bearing, the dirty condition of a modern engine crankcase or the detonation pressures.

Cylinders, Pistons and Rings

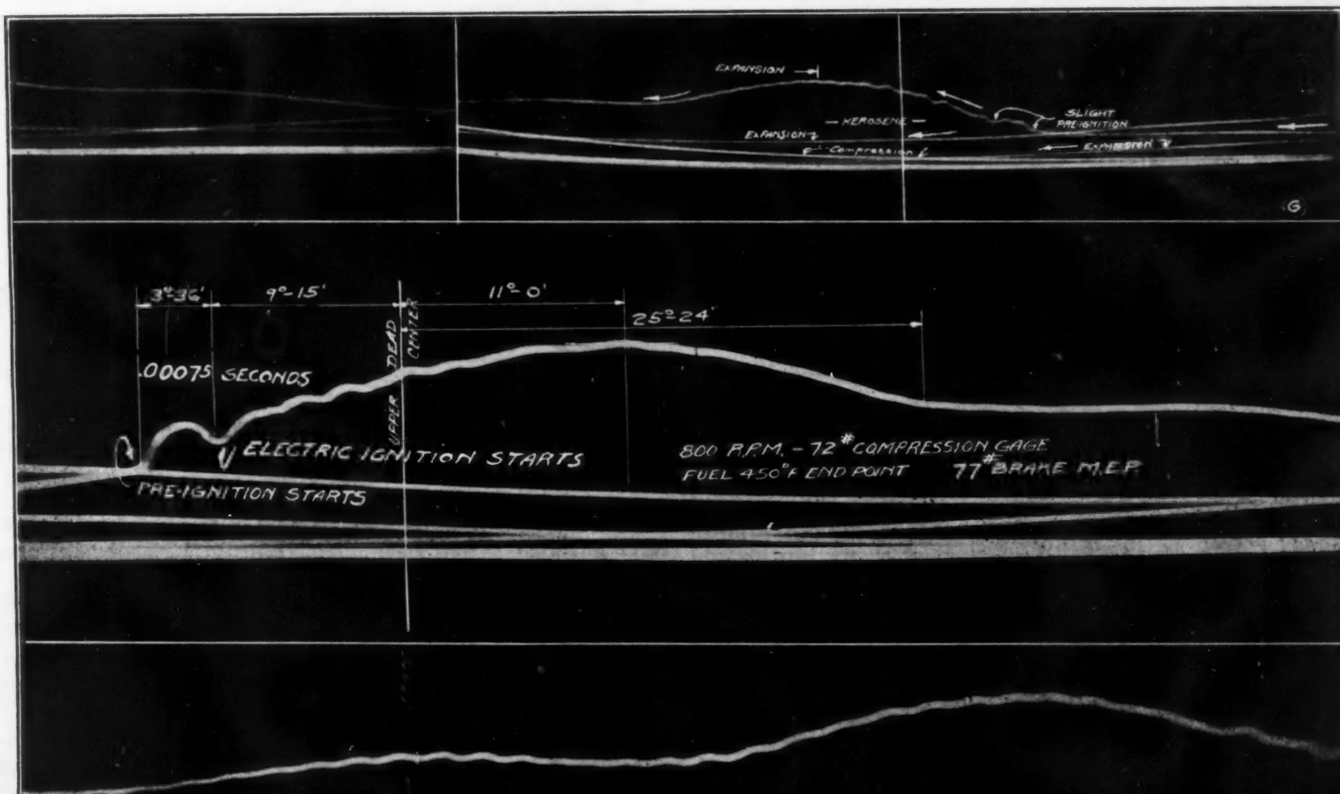
An ideal combustion chamber would be a sphere with a uniform wall thickness of uniformly high temperature yet not so hot as to cause decomposition of the fuel in use. Practical considerations make such a combustion chamber unattainable at present because of the cost and the element of design and compromises to meet other necessary conditions.

Heavy gasolines and kerosenes and fuel made by the cracking processes ranging in boiling points from 302 to 575 ignite at lower temperatures than better gasoline. Under the stress of temperature and pressure they detonate after the initial explosion. The pre-ignition is lost work and is damaging to the bearing. Pre-ignition may be the one cause of detonation. In the series of diagrams taken on an engine burning 56-deg. gasoline with an actual boiling point of 125 deg. fahr. and an end-point of 446 deg. fahr. you will notice what might be called a fairly good combustion. You will note the ignition point, which starts, comes to a maximum and then drops slightly. This is a mild pre-ignition which is much more common than supposed; in fact, this pre-ignition could not be heard. Outside the question of fuel composition the controlling factors with respect to a satisfactory combustion curve are:

(1) The temperature of the hottest spot in the combustion chamber
(2) The average combustion chamber temperature
(3) The temperature of the mixture coming through the intake valve
(4) The compression at the time of ignition

The ideal for which we have all been striving is the burning of all fuel down to heavy kerosene and even beyond by designing all the apparatus involved so as to meet the following specifications:

(1) No pre-ignition
(2) No detonation
(3) No breaking down of fuel
(4) Accomplished without water
(5) Accomplished without special fuels
(6) Accomplished without adding anything to fuel
(7) With fuel consumption approaching the best gasoline performance
(8) With a minimum loss of mean effective pressure



Manograph Charts of Explosions in an Engine Using 56-Deg. Gasoline Having a Boiling Point of 125 Deg. Fahr. and an End-Point of 446 Deg. Fahr.

To measure progress we have set up a yardstick of performance, using the ratio of fuel consumption per horsepower-hour to the brake mean effective pressure as the factor. The chart which is reproduced illustrates this point. In burning heavy fuels the greater the heat application the better the economy figure. The greater the heat the less the brake mean effective pressure. All devices attempt to keep the horsepower output as near to the gasoline output as possible by supplying a minimum of heat to the incoming mixture. You will note that great economy usually goes with low mean effective pressure.

By devices for thoroughly vaporizing the kerosene in the manifold, it is possible at this time even with our present knowledge to accomplish these results:

(1) To get within 10 per cent of the present gasoline horsepower
(2) To get equal economy of kerosene consumption to that now available with gasoline
(3) Using the same principles it is possible to improve gasoline economy to the extent of something better than 20 per cent

It has long been known in the art of coal gas making that combustible hydrocarbons formed under the high temperature conditions of the gas retort have such stability under heat that considerable heat energy is necessary to break them down or to change their atomic structure. Such fuels act with clean combustion lines. Compression pressure reaching far beyond anything used in practice today results in no pre-ignition detonations and insures increased horsepower outputs. Such fuels have the benzol ring as their bases and range down to naphthalene and anthracene. A mixture of these with ordinary gasoline or kerosene will eliminate the knock at good compression even when the benzol and its derivatives are low in percentage of weight of the fuel. In engines of poor design where knocking is common a much better horsepower can be got with these stable fuels.

Whether it is possible to produce fuels stabilized by the ring compounds is an economic problem which is now receiving the attention of the best business brains of this industry. Fuels are now being produced by cracking and other processes which bid fair to meet some of the demands for a better and lighter product.

In the cylinder hot spots cause the greatest trouble with modern fuels, and the cylinder walls, pistons and rings suffer due to the poor vaporization of the fuel. The heavier constituents of the fuel, because of the temperature at the top of the piston, mix with the lubricating oils which are passing upward and becoming more fluid and less lubricating to such an extent as to practically make them of no value. Deposits of dirt, dust and carbon on the cylinder walls all reduce the wearing life of the piston-ring and cylinder wall surfaces. Aside from better vaporization there is room for great improvement in piston and ring design. There is little hope of keeping low combustion chamber temperatures except through piston design.

Valves and Springs

Poppet valves are always a problem. Heavy fuels cause trouble at this point because of imperfect vaporization. Most valve troubles come because of carbon deposits, warping of cylinders and improper water circulation. It would be a great aid to the maintenance of good compression and valve seating to be able in a simple way to revolve the valve positively. Valves are damaged because of the unequal heating of the seats and stem. By revolving the valve slightly, each revolution distributes the heat load and eventually the valve develops an absolutely correct seat. Such a device, however, must not cause any more care, cost of maintenance or annoyance than the valve grinding. Valve springs suffer indirectly because of the fuel, due to the gumming of the stems.

Lubrication

Lubrication problems have been dealt with under the heading of bearings and cylinders. Under this heading we will deal briefly with lubricating oils. It is fortunate that the Bureau of Standards is taking up a program of investigation on lubricating oil, which when complete will give us the data that will be the basis of future lubrication. Generally speaking, most of the lubricating oil offered today by reliable refiners is designed entirely from the convenient viewpoint of the refiner and the hit-or-miss methods used for obtaining data from the users of

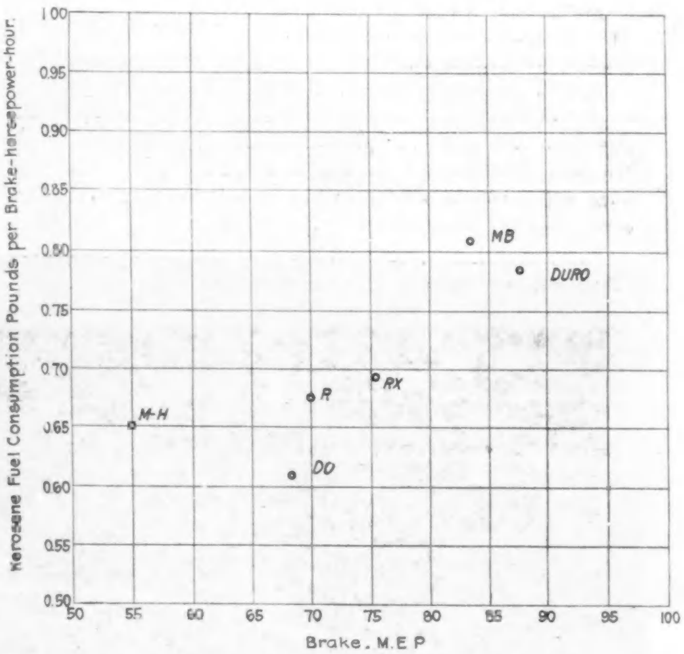


Diagram of the Relation Between the Fuel Consumption and the Brake Mean Effective Pressure in an Internal-Combustion Engine

the oil. It can be said that there is so much good oil in the worst of it and so much bad oil in the best of it that it behooves us all to investigate.

Lubricating oil can be considered of three parts: The light spindle oil, the medium weight and the heavy cylinder stock. In nearly all so-called good oils there is a portion in the medium content which constitutes the very essence of good lubricating qualities. This amounts to about 15 per cent of lubricating oils, and it would be impossible to supply the demand if this were the only oil accepted by the user. Oil companies virtually have to fill in with lighter oils to give a flow and heavy oils to give body and viscosity at the higher temperatures.

Light and even medium body oils evaporate at low temperatures and are thus the cause of excessive lubricating oil consumption. Heavy oils have complex molecules and break down under high temperatures. Light oils have no body or viscosity at a high heat. In rough terms, therefore, the oil which comes off at medium temperatures will not evaporate excessively at high temperatures nor disintegrate. In making aviation oil, a maxi-

mum of the good medium is used; in compounding a tractor oil a little of the lighter and the heavier is used with the good, and so on through the truck oils down to the small passenger car engines, where because of the low temperatures a maximum of the light, fair quantity of the good and a minimum of the heavy can be used. Based on this conception, oils are and will be available which give the maximum of service, the minimum of carbon and excellent lubrication. The above is a rough outline of my conception of the lubricating oil problem.

Starting Troubles

Vaporizing and atomizing defects in our present systems are the design faults affecting starting. The high boiling point of the first drop of fuel coming off in distillation tests of our gasolines is the characteristic in the modern fuels affecting starting. Because so little of the fuel can be vaporized at the intake manifold temperatures, large volumes of fuel beyond what would be necessary in an easily vaporized fuel are taken in. The result is that five times the fuel is taken in which is necessary to get the amount in the mixture that will produce an explosion. Engines start with difficulty at that, and all this amounts to inconveniences and bad blood between the user and the builder of modern engines.

Whatever inconvenience arises is nothing compared with the damage done to the combustion chamber by heavy fuel and to the lubricating oil by dilution when the engine is cold at starting. Perhaps 70 per cent of these troubles come from this source at the time of starting. Means for catching the heavy oil and preventing it from entering the combustion chamber must be provided.

Conclusion

Whatever may be the conclusion of business men or engineers as to the fuel problem, this paper, dealing with the subject of engine troubles as viewed by an engineer as a service man, certainly need present no further evidence to stamp definitely on our minds the fact that the fuel problem is before us and that the survival of the fittest will be the answer to the question as to who is burning our fuel well.

THE FUTURE OF AERONAUTICS[1]

I AM a great believer in the future of aeronautics. Shall I say its future when its present is so clearly established and so recognized by all those who will see? Already the American continent has been several times traversed by pilots in heavier-than-air machines. The Atlantic has been spanned by machines of the same type, while at this moment a crew of gallant men are, we hope successfully, piloting the first great dirigible across the Atlantic. British machines have flown from Egypt to Calcutta. Commercial lines have been established between various European points and others are in contemplation in a number of European countries. In view of all that is at present before us the future holds for us a prospect the limits of which are almost beyond vision.

I believe that the next war, if there shall be another war and our vaunted League of Nations will be shown to have not absolutely done away with this, will be fought by the two forces of the air, aircraft and chemical warfare. I am not going to treat of aircraft purely as a military arm. I am thinking of it as much, and perhaps more, with reference to its commercial future as I am to its military aspect, however great and commanding that may be. A few years ago we had in this country a great era of trolley building. That was before the days of the real development of the automobile. At that time the ownership of automobiles was limited to a very few rich men. Today its use has become so general, the familiarity of the public with it is so great and universal, that the use of the automobile has affected the trolley lines to such a degree that most of them are in financial difficulties. To what extent is the use of aircraft to parallel this experience with the steam railroads? Less than 60 days ago the president of one of the great railroad lines of this country said to me most seriously that he believed the railroads must prepare themselves for a material decrease in revenue from the carrying of mail, express and light freight and to some extent passenger traffic, on account of the use of aircraft.

In view of the romanticism attached to aeronautics it is perhaps a little singular that it has been so difficult a matter to obtain capital for its development, but this reminds me of something that Uncle Joe Cannon told me a short time ago as having happened in his own experience.

In the forties the conception of the telegraph was brought to the attention of Congress and an appropriation of $30,000 was asked to build a line between Baltimore and Washington. Congressman Wallace of Indiana voted for that appropriation. He was roundly denounced by a political opponent in these words: "You all know how hard it is to pay taxes with pork at $1.50 per 100 lb. and wheat at 30 cents per bu., and yet this man Wallace voted away $30,000 of your money on a scheme to send messages by lightnin'. Are you going to reelect a man who is that careless of the people's money?" Wallace was overwhelmingly defeated for reelection to make way for the more economical and conservative man.

Hot-air balloons had made ascents before the Declaration of Independence. The records of the United States Patent Office show that Rufus Porter took out a patent for a dirigible balloon in 1820, that he built a model of it which was tested successfully but never developed for the reason that he could not raise the money for the construction of the machine. The project was therefore dropped, and it was not until a great many years later that it was again brought forward in a serious way, and then it was not in this country but in Germany. The fact remains, however, that both the dirigible airship and the airplane are distinctively American inventions. We are prone to think of the development of the science as having been slow, but perhaps our impatience has something to do with that. Let us stop to consider that the first man to fly in a heavier-than-air machine is living with us today, only 48 yr. old. It is true after all that the development of aeronautics has been more rapid than that of steam navigation. It is a far cry from the day of the City of Savannah, which pioneered the way across the Atlantic just a century ago, to that of the Mauretania and the Leviathan. It was nearly 50 yr. before the Cunard Line put a 5000-ton boat into service. Vessels of this size were then looked upon as monsters of the deep. Today they would scarcely pass for fuel tenders for the Leviathan and the Mauretania. Our fathers laughed with Trowbridge at the ludicrous exploits of Darius Green but today we realize that Darius was simply a young man born ahead of his time.

I have been privileged to read the last report of the British Air Ministry. It reads more like a romance than a report to Parliament. It shows conclusively that our British cousins are alive to the possibilities of aeronautics.

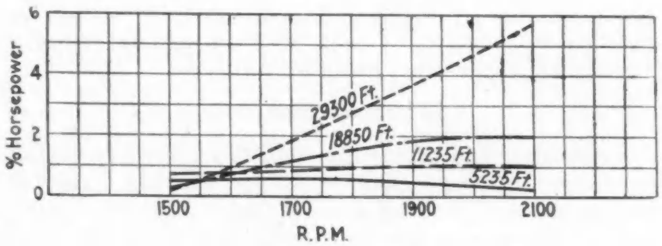
[1]From a speech delivered by Senator Harry S. New of Indiana at a dinner in honor of the crews of the NC flying boats who participated in the first transatlantic flight.

Power Characteristics of 20 Per Cent Benzol Mixture

THE following report is based upon tests made in the altitude laboratory of the Bureau of Standards. In this laboratory the engine under test is installed in a concrete chamber having insulated walls from which the air can be partially exhausted by a blower, thus reducing the barometric pressure within the chamber to that corresponding with any desired altitude, up to 30,000 ft. As it enters the chamber, the air is passed over a series of refrigerating coils, and by this means the temperature can be regulated during the tests. The engine is coupled directly to an electric dynamometer placed outside the chamber, by which the power of the engine can be absorbed and measured.

The fuel herein called "Signal Corps Mixture," hereafter referred to as S.C.M., is a special blend of gasoline and benzol made up to specifications prepared by W. E. Perdew, assistant chemical engineer of the Bureau of Mines, and presented to the Science and Research Division of the Signal Corps, U. S. Army, as follows:

> The blend shall consist of 20 per cent by volume of commercial "90 per cent benzol" and 80 per cent by volume of a special straight-run gasoline. The blending or mixing shall be thorough so that all the individual containers will contain fuel of exactly the same composition.



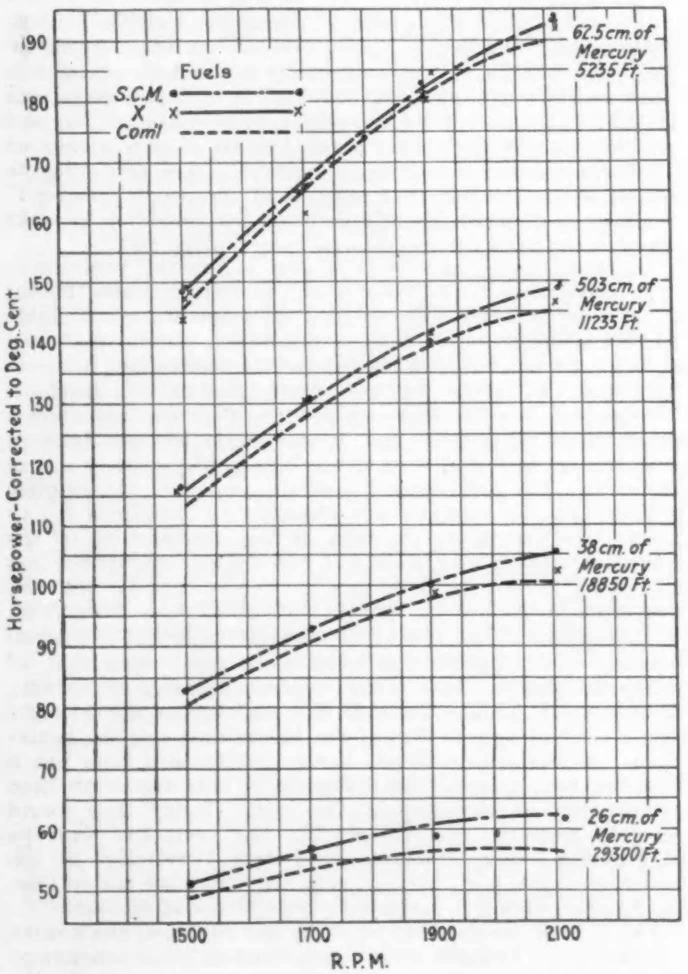
GAIN IN THE HORSEPOWER OF A HISPANO-SUIZA ENGINE AT VARIOUS SPEEDS DUE TO THE USE OF THE SIGNAL CORPS MIXTURE AS COMPARED WITH THE STANDARD X FUEL

Specifications for Benzol

Color—Water white
Initial boiling point—Not lower than 74 deg. cent.
90 per cent off at 86 deg. cent. or below
95 per cent off at 95 deg. cent. or below
End point, not above 150 deg. cent.

Specifications for Special Gasoline

Color—Water white
Odor—Not specified
Unsaturated—No products of any cracking process
Doctor—No requirements
Distillation loss—Not more than 2 per cent
Recovery—Not less than 97 per cent
Distillation, first drop, not below 50 deg. cent. nor above 65 deg. cent.
20 per cent not above 80 deg. cent.
50 per cent not above 100 deg. cent.
70 per cent not above 115 deg. cent.
90 per cent not above 135 deg. cent.
Dry point not above 177 deg. cent.

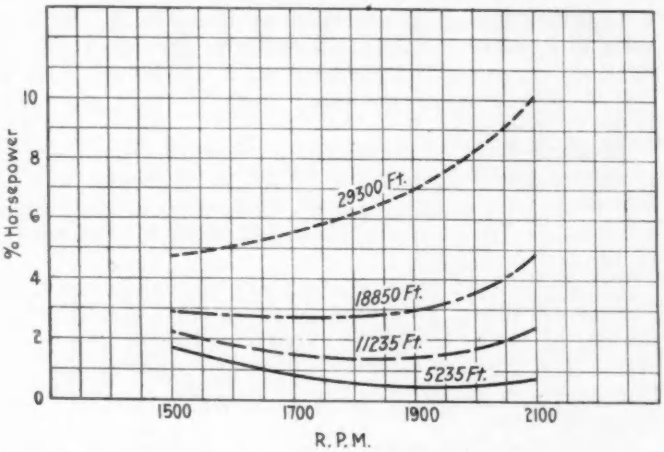


HORSEPOWER-SPEED CURVES OF THE HISPANO-SUIZA ENGINE USING DIFFERENT FUELS

The engine employed in these tests was a 180-hp. type E Hispano-Suiza, built by the Wright-Martin Aircraft Corporation, New Brunswick, N. J. It has eight cylinders in blocks of four, set at 90 deg., and the following dimensions: bore, 4.725 in.; stroke, 5.118 in., and compression ratio or total volume to clearance, 5.3. The engine was operated under pressures of 62.5, 50.3, 38.0 and 26.0 cm. of mercury, corresponding to four altitudes of 5235, 11,235, 18,850 and 29,300 ft. and at four speeds of 1500 1700, 1900 and 2100 r.p.m. at each altitude.

The carbureter was carefully adjusted by hand for each test to secure the maximum horsepower at that particular speed and altitude with the leanest mixture. In making these adjustments the carbureter was first set to secure the maximum possible brake pull regardless of fuel consumption. The fuel supply was then cut down until the power fell off. Then the gasoline flow was gradually increased, until the maximum brake pull was again secured.

In these tests two sets of runs were made at the various speeds at each barometric pressure, one on the fuel being tested, the other, immediately before or after, with a comparison fuel known to the laboratory as Standard X. This method of observation insured that the engine was in practically the same condition during the runs on each fuel. The fuel designated as Standard X and manufactured by the Atlantic Refining Co. as one of its



GAIN IN THE HORSEPOWER OF A HISPANO-SUIZA ENGINE AT VARIOUS SPEEDS DUE TO THE USE OF THE SIGNAL CORPS MIXTURE AS COMPARED WITH COMMERCIAL GASOLINE

the approximate horsepower at each speed and pressure was obtained. These, in turn, were plotted against atmospheric pressure. In this plot, the points lie very nearly on a straight line. It was found that three out of the four points did actually lie upon a straight line and the other very close to it. Replotting the horsepowers obtained from the straight lines against speed a second time, showed the probable error in plotting, and by carefully repeated trials the curves reproduced were obtained. In this way, the results obtained at one altitude were used to check the results obtained at the others.

One feature of the lines of horsepower plotted against barometric pressure was particularly helpful in this method of analysis. It was found that the intercepts of these lines on the axis of zero pressure were quite evenly spaced. For example, in the equation for the line

$y = ax - b$

wherein y = horsepower

x = barometric pressure in cm. of mercury

HORSEPOWER AND HORSEPOWER RATIOS FOR S.C.M., X AND COMMERCIAL GASOLINE AT VARIOUS SPEEDS AND ALTITUDES

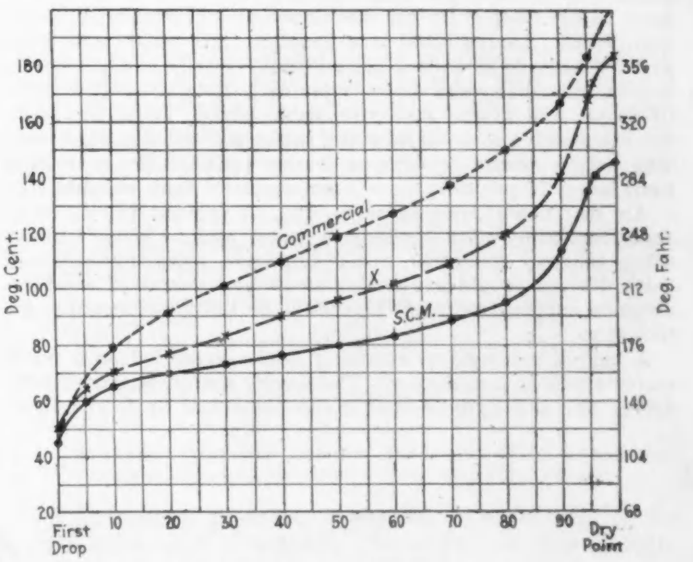
Altitude, ft.	Pressure in cm. of mercury	Speed, r.p.m.	Horsepower Developed Corrected to 0 deg. cent. S.C.M.	X	S.C.M.-X	Com'l	Horsepower Ratio, per cent S.C.M.-Com'l	S.C.M.-X / X	S.C.M.-Com'l / Com'l
5,235	62.5	2,100	192.0	191.5	0.5	189.5	1.5	0.261	0.75
		1,900	182.0	181.0	1.0	181.1	0.9	0.550	0.50
		1,700	166.7	165.7	1.0	165.2	1.5	0.604	0.91
		1,500	148.2	147.5	0.7	145.6	2.6	0.475	1.78
11,235	50.3	2,100	148.6	147.0	1.6	145.0	3.6	1.088	2.40
		1,900	141.5	140.0	1.5	139.5	2.0	1.071	1.43
		1,700	129.8	128.8	1.0	127.9	1.9	0.776	1.49
		1,500	115.7	114.8	0.9	113.3	2.4	0.785	2.12
18,850	38.0	2,100	105.0	102.5	2.5	100.2	4.8	2.000	4.80
		1,900	100.5	98.6	1.9	97.6	2.9	1.890	2.97
		1,700	92.7	91.7	1.0	90.2	2.5	1.090	2.77
		1,500	83.0	82.8	0.2	80.7	2.3	0.240	2.85
24,300	26.0	2,100	62.3	58.9	3.4	56.6	5.7	5.780	10.07
		1,900	60.6	58.4	2.2	56.7	3.9	3.770	6.88
		1,700	56.6	55.6	1.0	53.6	3.0	1.800	5.60
		1,500	51.2	51.1	0.1	48.9	2.3	0.196	4.69

standard products, fulfills the specifications of the Bureau of Aircraft Production for aviation gasoline.

As a matter of interest, the performance of commercial gasoline has been tabulated and plotted with the results obtained from the other fuels. The values for Commercial have been tabulated by percentage differences between this fuel and the X secured in another test. Commercial gasoline is a fair sample of the fuel usually sold at automobile filling stations and is of a lower grade than the Standard X. It was purchased under the U. S. General Supply Committee specification for 1918.

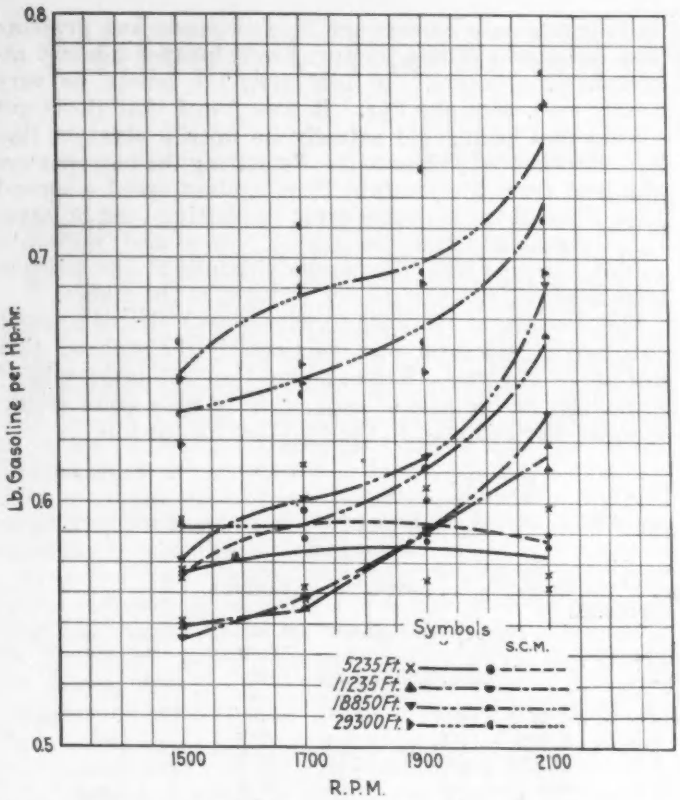
In order that a fair comparison of the performance of the engine with the various fuels could be made, the horsepowers in each case were corrected to 0 deg. cent. In working up the data secured from these tests, it was found that the horsepower differences, particularly at the lower altitudes, were so small as to make the usual method of fairing curves too uncertain. This can easily be understood by reference to the plotted horsepower-speed curves. It will be readily seen that several curves could be drawn through the points obtained from the tests at 5235 ft., any one of which might be considered as an average of the results. One set of curves might show S.C.M. higher than X, and another, equally fair, might show S.C.M. lower than X. It was obvious therefore that some better method should be employed.

By drawing fair curves through the observed points



DISTILLATION CURVES OF THE DIFFERENT FUELS TESTED

the values of b increased by even increments, for even differences of speed. This method was employed for all three fuels involved, and these results are also given in tabular form.



FUEL CONSUMPTION-SPEED CURVES FOR THE STANDARD X AND THE SIGNAL CORPS MIXTURE AT DIFFERENT ALTITUDES AND SPEEDS

In the curves of the horsepowers of S.C.M., X and commercial gasoline at various barometric pressures, plotted against speed, a considerable gain in horsepower of S.C.M. over both of the other fuels at the higher altitudes is shown.

In another set of curves the percentage gain in power is plotted against speed for S.C.M. as compared with X and with commercial gasoline. This set of curves simply accentuates the characteristics indicated by the curves in the previous figures.

The distillation curve of the fuel obtained by the U. S. Bureau of Mines, according to the method described in Bureau of Mines Technical Paper No. 166, is also reproduced, and for the purpose of comparison the distillation curves of X and commercial gasoline are plotted on the same sheet.

The actual fuel consumption in pounds per horsepower-hour was plotted against speed. The curves are drawn through the arithmetical means of the various points determined. On account of the unsatisfactory operation of the fuel weighing device which was employed in conducting the tests these results should be considered as being only comparative and not final.

From these tests the Bureau concludes that the Signal Corps Mixture shows very little gain in power as compared with X below an altitude of 10,000 ft. Above that altitude there is no gain of consequence at the lower speeds, but a marked gain at the higher speeds. It is therefore to be considered a high-altitude fuel. The fuel consumption would be about 4 per cent greater than X at the altitude where the fuel gives its best performance.

PROBLEMS IN AIRPLANE EQUIPMENT

THE equipment section of the engineering division of the Army Air Service is anxious that inventors and designers in general and members of the Society in particular lend their efforts in the development of certain airplane equipment. Among these is a gasoline tank which will withstand a salvo of 30 calibre ammunition, equally mixed, service, tracer, incendiary and armor-piercing bullets, fired at a range of 30 yd. and at the most vulnerable angle. There are to be ten consecutive tests on as many tanks without fire occurring. The weight should be kept as low as possible, the maximum limit being 75 per cent more than standard tank weights.

Air bag floats, landing skids, etc., to prevent the machine from capsizing when landing in water and to keep it afloat after landing constitute other problems requiring solution. Such devices should present as small an amount of wind resistance surface as possible, should be light and readily detachable.

A mobile independent cranking device, mounted on a small motor truck is also desired. The device should be electrically driven and arranged so that it can be backed up to the front end of an airplane and attached to the propeller by a flexible arm. The electric motor is then used to crank the engine, causing it to begin firing. When the engine picks up, the device should be automatically thrown out of connection with the propeller.

A gasoline supply gage is needed which will be responsive, serviceable and accurate to the last half gallon. It may be mounted on the tank, although it should preferably be mounted on the dashboard. This gage must, of course, register under conditions existing in airplane service where the center line of the tank changes rapidly from one to another of practically every plane that it is possible to assume, and is frequently 180 deg. out of its normal position for comparatively short intervals of time.

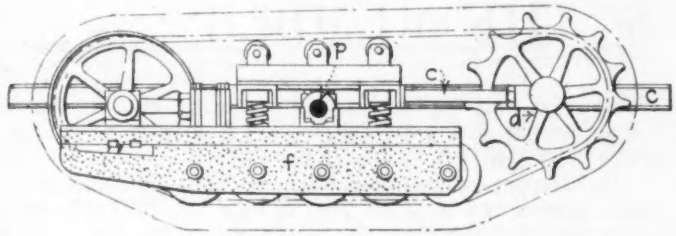
At present portable canvas hangars for field service do not weather winds or rainstorms well enough to be practical, and they are generally too small. The improved hangar should be capable of housing four De Haviland planes with working space. They should provide for the necessary electric lighting and small machine work.

Types of Tracklayer Tractors

IN view of developments in the tank-type or chain-track tractor, a comparison of the frames which carry the load-supporting rollers is both interesting and instructive. These tractors are fitted with side frames each with a front idler for the chain track and a series of flanged rollers traveling upon the lower run of the track. Such side frames, with but few exceptions, are provided with pivots which allow vertical movement of these frames relative to the main frame of the vehicle.

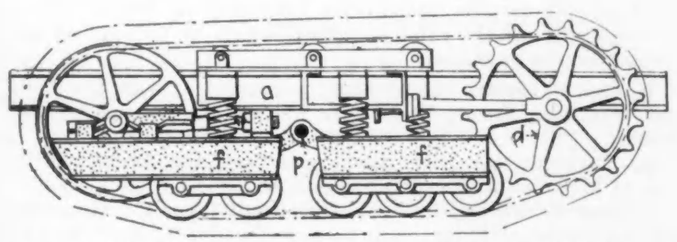
In the diagrams, the pivots for the side frames are represented in solid black, so that the side frames are free to move with relation to the main frame of the tractor about this black disk.

The letter *c* indicates the chassis or main frame, *d* the chain-track driving sprocket, *f* the truck frame or side traction frame and *p* the pivot in each of the six diagrams.



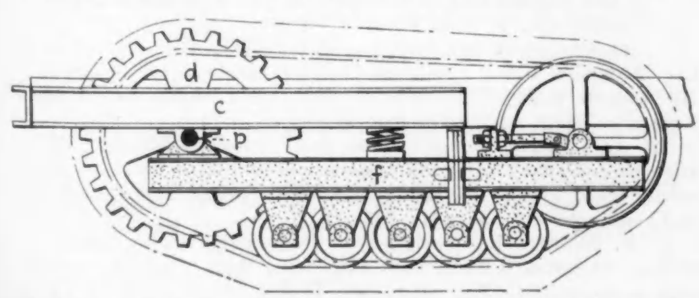
A Caterpillar Tractor with the Load-Supporting Rollers Mounted on the Truck Frames

In the caterpillar machine shown in the first two drawings, the load-supporting rollers are mounted on truck frames, which are pivoted to the main frame approximately at the central point of such truck frames. The chain-track driving sprocket is journalled on the main frame and is entirely independent of the trucks.

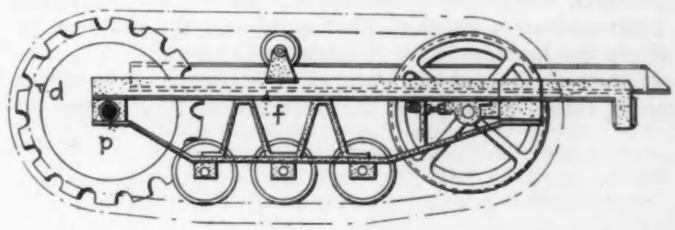


In This Smaller Caterpillar Tractor the Driving Sprocket Is Journalled on the Main Frame

In the tractor shown in the next illustration the side traction frame is fulcrumed upon the rear axle for the driving sprocket. An American tractor, also with the side traction frames pivoted about the rear axle, is illustrated, but, in this example, the traction frames are continued to the front of the main frame. In the next view both the front idler and the rear driver are journalled on the side traction frame; this represents the "creeping grip" construction. The driving sprocket is operatively engaged by a lantern wheel. Another form of drive to a sprocket journalled in the side traction frame is also shown. Upon the pivot is a sleeve having two toothed wheels, one of which is chain driven from the main frame and the other of which drives a chain wheel coaxial with the chain-track driving sprocket.

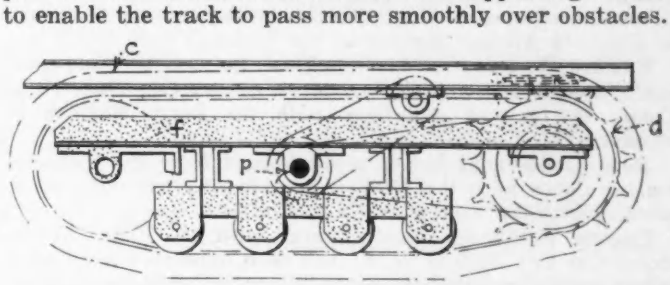


A Tractor Having the Side Traction Frame Fulcrumed on the Rear Axle



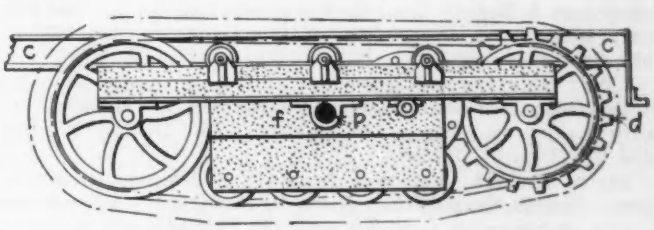
A Type of Tractor in Which the Side Traction Frames Are Pivoted About the Rear Axle but Continue to the Front of the Main Frame

These various methods of connecting the side frames to the main frame all have the same principal object; to provide for vertical movements of the supporting rollers to enable the track to pass more smoothly over obstacles.



The So-Called Creeping Grip Tractor, Having the Rear Driver and Idler Journalled on the Side Traction Frame

They therefore correspond to the springing of the axles of a motor car, but with this difference, that, in the latter case, each wheel is lifted individually as it strikes the obstacle, whereas, in the chain-track vehicle, all the rollers on the side frame must pivot together with that frame.



In a Recently Invented Tractor the Drive Is to a Sprocket Wheel Journalled on the Side Traction Frame

With central pivoting, when the forward end of the track rises upon an obstacle, the pivot and, consequently, the main frame at that point will be raised approximately one-half of the height of the obstacle, and as the tractor advances it is raised still more to the entire height of the obstacle as the pivot itself passes over the latter, to be thereafter gradually lowered to the half height as the last roller passes over the obstacle and further lowered

to its normal position as the sloping run of the chain passes up to the driving sprocket. Thus the rise and fall take place under similar conditions. In the case of the multiple-articulated trucks, since the truck can yield intermediately, the height of rise and fall is reduced, the chain track being subject to a contrary flexure which allows it to maintain contact with the ground on each side of a moderately high obstacle.

With end pivoting of the frame about the sprocket axle, the initial lift imparted to the frame is reduced by the increased deflection of the spring due to the movement of the center of support, that is to say, the distance by which the leading roller overhangs the center one. The advance of the vehicle reduces this overhang until the center roller passes over the obstacle, at which moment the spring carries its normal load and the main frame has been raised by the full height of the obstacle. Farther advance of the vehicle transfers a portion of the load to the frame pivot, thereby relieving the spring, which, consequently, expands sufficiently to bring the leading roller again into action at about the moment when the last roller is passing over the obstacle. The main frame of the vehicle has then to be lowered through the entire height of the obstacle during the upward travel of the sloping run of the chain. Apparently this sudden fall of the vehicle will produce a much greater jolt than in the former system because the height of the fall is double. On the other hand, the latter system affords a more gradual rise to offset the drawback of the sudden fall.—*The Commercial Motor.*

PERSONAL NOTES OF THE MEMBERS

Walter O. Adams has moved his office as a consulting production sales engineer from Detroit to Ann Arbor, Mich.

H. W. Alden, vice-president of the Timken-Detroit Axle Co., Detroit, Mich., has been awarded the Distinguished Service Medal for his work in connection with the development of tanks. Mr. Alden served as a lieutenant-colonel in the engineering division of the Ordnance Department and had charge of the tank development work during the war. He presented a paper dealing with the development of the tanks at the 1919 Annual Meeting of the Society.

Edward W. Beach has resigned as vice-president and general manager of the Manufacturers Foundry Co., Waterbury, Conn., and is now associated with the Ferro Machine & Foundry Co., Cleveland, Ohio.

John A. Cervenka has been discharged from the Quartermaster Corps with the rank of captain and has accepted a position with the Templeton-Kenly Co., Ltd., Chicago, Ill.

Francis W. Davis, truck engineer with the Pierce-Arrow Motor Car Co., Buffalo, N. Y., has been appointed a member of the truck standards committee of the National Automobile Chamber of Commerce for the coming year.

F. G. Diffin, president of the United Aircraft Engineering Corporation, New York City, recently sailed for Liverpool and will establish a branch of his organization at London.

W. E. Duersten has resigned as superintendent of the No. 2 plant of the Firestone Tire & Rubber Co., Akron, Ohio, to accept a position as vice-president with the New Castle Rubber Co., New Castle, Pa.

George N. Duffy has accepted a position with the Curtiss Aeroplanes & Motors, Ltd., Toronto, Ont., Canada. He was formerly general superintendent of the Canadian Aeroplanes, Ltd., also of that city.

A. W. Frehse has been appointed chief engineer, automotive division, Standard Steel Car Co., Pittsburgh, Pa. He was formerly a sales engineer in the employ of the Detroit Pressed Steel Co., Detroit, Mich.

Charles Froesch, who was formerly a designer with the Fergus Motors Corporation, Newark, N. J., has accepted the position of designing engineer with the Biddle Motor Car Co., New York City.

Richard H. Hall, Jr., who has been serving in the Quartermaster Corps with the rank of first-lieutenant, has been discharged from the service and is now located at Dearborn, Mich.

C. L. Halladay has severed his connection with the Jackson Motors Corporation, Jackson, Mich., to accept a position with the Maxwell Motors Co., Inc., Detroit, Mich.

Carl F. Heinemann has resigned as an engineer with the Vulcan Mfg. Co., Seattle, Wash., to accept a position with the Davis Car Co., also of that city.

R. K. Jack, who has been an engineer with the Olds Motor Works, Lansing, Mich., for the past six months, has been appointed chief engineer of the organization.

V. C. Kloepper has resigned as chief engineer of the automotive Department, National Tool & Mfg. Co., St. Louis, Mo. He has not made any plans for the future.

L. T. Knocke, has resigned as experimental engineer with the Waukesha Motor Co., Waukesha, Wis., to accept a position as chief engineer with the Falls Motors Corporation, Sheboygan Falls, Wis.

Thomas G. La Manna, who was chief designer for the Pomilio Brothers Corporation Aviation Experimental Works, Indianapolis, Ind., during the war, has accepted a position as mechanical engineer with the Piersen Telegraph Transmitter Co., Topeka, Kan.

Will I. Lewis has been transferred from the service department of the Hudson Motor Car Co., Detroit, Mich., to the Chicago office of the same company, where he will act as assistant service manager.

Warren P. Louden has severed his connection with the Morgan Mfg. Co., Keene, N. H. He has made no plans for the future.

M. Matthews has been discharged from the Army and is now at his home in West LaFayette, Ind.

Clifford A. Miller has been discharged from the Quartermaster Corps with the rank of first-lieutenant, and has accepted a position as chief engineer with the Jones Gear Co., Cleveland, Ohio.

J. H. Nead, formerly metallurgical engineer, Minneapolis Steel & Machinery Co., Minneapolis, Minn., and later attached to the technical staff of the War Department, has been appointed research metallurgist with the American Rolling Mill Co., Middletown, Ohio.

Nelson B. Nelson has resigned as chief draftsman with the Sterling Motor Truck Co., Milwaukee, Wis., to accept a position in the engineering department of the J. I. Case Threshing Machine Co., Racine, Wis.

J. George Oetzel has been appointed designing engineer of the Dominion Steel Products Co., Brantford, Ont., Canada. He was formerly assistant to the works engineer at the Erie, Pa., plant of the General Electric Co.

M. L. Pulcher, vice-president and general manager, Federal Motor Truck Co., has been appointed a member of the motor truck committee of the National Automobile Chamber of Commerce for the year 1919-20.

W. F. Rossiter has resigned as metallurgist with the McKinnon Industries, Ltd., St. Catharines, Ont., Canada, to accept a similar position with the Wright Roller Bearing Co., Philadelphia, Pa.

Everett M. Schultheis has resigned his position as designer with the Premier Motor Corporation, Indianapolis, Ind., to become an experimental designer with the Lynite Laboratories of the Aluminum Castings Co., Cleveland, Ohio.

Frank E. Smith has been discharged from the Air Service with the rank of lieutenant-colonel and has resumed his practice as an industrial engineer, with offices at 512 Fifth Avenue, New York City.

B. M. Sternberg, vice-president, Sterling Motor Truck Co., West Allis, Wis., has been named a member of the truck standards committee of the National Automobile Chamber of Commerce for the year 1919-20.

Edwin M. Sutherland has been transferred from the Chicago office of the Willard Storage Battery Co. to the Cleveland office of that organization, where he will act as sales engineer.

F. J. Vonachen has been discharged from the Ordnance Department with the rank of lieutenant and has accepted a position as automotive engineer with the Aluminum Castings Co., Cleveland, Ohio.

F. George Walker, who was formerly president and sales manager of the Walker Joint Co., Detroit, Mich., has been appointed Eastern district sales manager for the Fuller & Sons Mfg. Co., Kalamazoo, Mich., with offices at 222 American Circle Building, New York City.

Erwin A. Weiss has resigned as chief draftsman and engineer with the Service Motor Truck Co., Wabash, Ind., to accept a position with the Excelsior Motor Mfg. & Supply Co., Chicago, Ill.

E. A. Whitten, chief engineer, General Motors Truck Co., Pontiac, Mich., has been appointed a member of the truck standards committee of the National Automobile Chamber of Commerce for the coming year.

John Whyte has opened an office at 1101 Monadnock Building, Chicago, Ill., to practice as a consulting and designing automotive engineer. He was formerly chief engineer of the Bailey Non-Stall Differential Corporation, also of that city.

Applicants *for* Membership

The applications for membership received between July 17 and Sept. 8, 1919, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ANTHONY, ARTHUR H., general manager, Massillon Steel Casting Co., *Massillon, Ohio.*

ATHERTON, C. H., general manager, Zimmerman Steel Co., *Bettendorf, Iowa.*

BAASCH, CHARLES, owner, Charles Baasch, 1823 Broadway, *New York City.*

BEAL, FAY C., Auto Track Tractor Syndicate, 414 Insurance Exchange Building, *San Francisco, Cal.*

BENNETT, W. BURR, chief engineer and president, Wayne Engineering Co., *Honesdale, Pa.*

BIGGAR, P. E., student, McGill University, *Ottawa, Ont., Canada.*

BIKLE, WILLIAM F., design and construction engineer, Crawford Automobile Co., *Hagerstown, Md.*

BIRCHLER, HARRY I., mechanical draftsman, Fifth Avenue Coach Co., *New York City.*

BOCKMANN, ARTHUR C., automobile electrician, Union Automobile Co., Inc., *Union Hill, N. J.*

BONDAR, A. K., aeronautical engineer, Hannevig Sikorsky Aircraft Co., *New York City.*

BROOKS, HENRY W., Western sales manager, General Ordnance Co., *Cedar Rapids, Iowa.*

BUTTERWORTH, THOMAS C., engineer, Rogers Una-Drive Motor Truck Corporation, *Sunnyvale, Cal.*

CAVANAGH, EVERETT, sales engineer, Bimel Spoke & Auto Wheel Co., *Portland, Ind.*

CAVANAGH, JAMES F., president and general manager, Northway Motors Corporation, *Boston, Mass.*

CEDERLEAF, FRED W., chief engineer, Sparks-Withington Co., *Jackson, Mich.*

CHURCH, RUPERT N., designing and experimental work, Challoner Co., *Oshkosh, Wis.*

CONROY, T. M., plant superintendent, Willys Morrow Co., *Elmira, N. Y.;* Gramm Motor Truck Co., *Lima, Ohio;* Willys-Overland Co., *Elyria, Ohio,* and Willys-Overland Co., *Toledo, Ohio.*

CRAWFORD, JOHN D., consulting engineer in charge of research and development, Maryland Pressed Steel Co., *Hagerstown, Md.*

DAVIES, J. E., president, Alberta Foundry & Machine Co., Ltd., *Medicine Hat, Alta., Canada.*

DAVISON, RALPH E., assistant superintendent, Curtiss Engineering Corporation, *Garden City, N. Y.*

DAVISON, V. A., sales manager, Cincinnati Ball Crank Co., *Cincinnati, Ohio.*

DEADY, EMMETT F., truck designer, Duplex Truck Co., *Lansing, Mich.*

DEAN, EDWARD E., field engineer, Byrne Kingston Co., *Kokomo, Ind.*

EASTMAN, ROBERT L., designer, tractor department, Electric Wheel Co., *Quincy, Ill.*

EDSCORN, G. E., automotive engineer, Wagner Electric Mfg. Co., *St. Louis, Mo.*

FOSTER, HARRY C., master mechanic, Indiana Lamp Co., *Connersville, Ind.*

FYKE, FRANK C., chief testing engineer, Standard Oil Co., *Elizabeth, N. J.*

GARVEY, HARRY V., western sales manager of automotive division and machine designer, Fairbanks Co., *Chicago, Ill.*

HAVENS, FRANCIS H., draftsman, Kalamazoo Railway Supply Co., *Kalamazoo, Mich.*

HENRY, FERDINAND G., chief engineer, George White Co., *Jersey City, N. J.*

HILL, THOMAS MARTIN, designing draftsman, Electric Wheel Co., *Quincy, Ill.*

HOLDEMAN, L. H., assistant engineer, Stearns Motor Mfg. Co., *Ludington, Mich.*

HOSHIKO, ISAMU, chief engineer, Tokyo Gas & Electric Engineering Co., *Tokyo, Japan.*

JESCH, PAUL J., draftsman and designer, Brewster & Co., *Long Island City, N. Y.*

KAUFMAN, OTTO H., sales manager and technical advisor, Challoner Co., *Oshkosh, Wis.*

KELLOGG, RALPH S., layout draftsman, Dort Motor Car Co., *Flint, Mich.*

KERN, ROY S., instructor in gas engines, Virginia High School, *Virginia, Minn.*

KNOCH, F. E., general superintendent, United Oil Co., *Florence, Colo.*

KNOPP, W. R., sales department engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

KNUDSEN, H. L., chief engineer, Iron Mountain Co., *Chicago, Ill.*

KUIPER, GERHARD CORNELIUS R., draftsman, Jordan Motor Car Co., *Cleveland, Ohio.*

LARSON, JESSE L., factory superintendent, Oklahoma Auto Mfg. Co., *Muskogee, Okla.*

LEGG, WILLIAM F., mechanical engineer, 3657 Broadway, *New York City.*

LOUNSBERRY, FRANK B., metallurgist, Atlas Crucible Steel Co., *Dunkirk, N. Y.*

MAHOUX, GEORGES, chief of technical department, Société Lorraine des anciens, Etablissements de Dietrich & Cie. de Luneville, à *Argenteuil* (Seine et Oise), *France.*

MENCH, EUGENE L., JR., engineer, Mutual Truck Co., *Sullivan, Ind.*

MORRIS, HARRY T., metallurgical engineer, Bethlehem Steel Co., *Bethlehem, Pa.*

NIEHOFF, PAUL G., president and general manager, Paul G. Niehoff & Co., Inc., *Chicago, Ill.*

O'NEAL, ERNEST P., electrical engineer, International Motor Co., *New York City.*

PHELPS, ALVAN W., machine designer, Chevrolet Motor Co., *Flint, Mich.*

PIERCE, LESLIE EDWARD, airplane section, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

POHLMANN, EDWARD CHARLES, assistant editor, *American Garage and Auto Dealer, Chicago, Ill.*

PRUDEN, RICHARD M., foreman, experimental department, Advance Rumely Co., *LaPorte, Ind.*

PUSEY, WESLEY B., farm tractor designer, General Ordnance Co., *Derby, Conn.*

RALSTON, JAMES M., *Allenhurst, N. J.*

REDMOND J. CHARLES, Eastern manager, Michigan Steel Casting Co., *Detroit, Mich.*

REYNDERS, A. B., works manager, East Springfield Works, Westinghouse Electric & Mfg. Co., *Springfield, Mass.*

ROBOTTI ITALO, chief of technical publication office, Fiat Co., *Turin, Italy.*

ROGES, CLARENCE E., chief engineer, Huffman Brothers Motor Co., *Elkhart, Ind.*

RUDICK, O. W., recorder of design, changes and engineering records, Continental Motors Corporation, *Detroit, Mich.*

SANDERS, R. H., draftsman, Duplex Engine Governor Co., *Brooklyn, N. Y.*

SEGRAVES, J. H., transportation engineer, Heavy Haulage Co., *New York City.*

SHUART, ARTHUR C., layout draftsman, Reed & Glaser, *Indianapolis, Ind.*

SIMMONDS, EDGAR P., assistant material inspector and surveyor at large, Pittsburgh Office, Bureau Veritas, *New York City.*

TOMPKINS, J. E., service manager, Couch-Haas Co., Inc., *Brooklyn, N. Y.*

TRUESDELL, FRED. ADRIEN, assistant engineer and chief draftsman, experimental tractor department, Van Dorn Iron Works, *Cleveland, Ohio.*

VAN METER, M., engineer, Acme Motor Truck Co., *Cadillac, Mich.*

VANSANT, HARRY C., boatbuilder, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

WALKER, CLARENCE S., patent counsel, Wire Wheel Corporation of America, *Buffalo, N. Y.*

WELLMAN, S. K., engineer, Van Dorn Iron Works, *Cleveland, Ohio.*

WHISLER, T. CLIFFORD, tractor designer, General Ordnance Co., *Derby, Conn.*

WIDNEY, STANLEY W., president and manager, Widney Co., 320 South Jefferson Street, *Chicago, Ill.*

WILLIAMS, CHARLES LESLIE, designer, Buick Motor Co., division of General Motors Corporation, *Flint, Mich.*

WINNING, ROBERT K., chief engineer, Clum Mfg. Co., *Milwaukee, Wis.*

YOUNG, GORDON R., CAPT., engineering branch, Motor Transport Corps, Seventh and B streets, N. W., *Washington.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between July 15 and Aug. 15, 1919. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment; (S. M.) Service Member; (F. M.) Foreign Member.

ADLER, H. GEORGE (A) engineer, electrical division, Duplex Engine Governor Co., *Brooklyn, N. Y.*, (mail) 592 Hinsdale Street.

ANNIS, LIEUT. EMMETT FRANK (S. M.) army inspector of ordnance, Reo Motor Car Co., *Lansing, Mich.*, and Maxwell-Chalmers Motor Car Co., Detroit, (mail) care of Reo Motor Car Co.

AUMENT, CARROLL M. (M) chief engineer, Phianna Motors Corporation of New York, Long Island City, N. Y., (mail) 87 Nassau Street, *New York City.*

BAKER, WILLIAM A. (A) assistant engineer in charge of equipment business, Eastern states, Silvex Co., *South Bethlehem, Pa.*

BRODIE, RALPH NATHAN (J) president and chief engineer, Empire Machine Tool & Engine Co., 461 Third Street, *Oakland, Cal.*

BEMAN, RALPH (M) engineer, standardizing department, National Lamp Works of General Electric Co., *Cleveland, Ohio;* (mail) Nela Park.

BLAIR, RALPH K. (M) works manager and assistant general manager, Brewster & Co., *Long Island City, N. Y.*

BROWN, J. CLIFTON (A) proprietor, Willard Storage Battery service station, 105 North Main Street, *Sumter, S. C.*

BURTIS, WARREN H. (A) superintendent, mechanical department, Oregon State Highway Commission, *Salem, Ore.*, (mail) 1937 State Street.

DREYFUS, ALEX. F. (A) manager, City Sales Agency, Inc., Howard Avenue and Baronne Street, *New Orleans, La.*

FARMER, EARL H. (M) chief engineer, H. E. Wilcox Motor Co., 1030 Marshall Street, N. E., *Minneapolis, Minn.*

FOSTER, SHUBEL A. (M) manager, service and garage departments, Britton Co., 121 Allyn Street, *Hartford, Conn.*

GILL, JOHN D. (M) technical advisor to general sales manager, Atlantic Refining Co., 1211 Chestnut Street, *Philadelphia, Pa.*

GREUTER, R. E. (J) engineer, Petroleum Engine & Mfg. Co., Room 3010, 120 Broadway, *New York City.*

GROVER, RAY (M) chief engineer, Le Roi Co., *Milwaukee, Wis.*, (mail) R. F. D. 2, Box 56.

HOGAN, HERBERT J. (A) general foreman, sheet metal division, Nordyke & Marmon Co., *Indianapolis, Ind.*, (mail) 2526 North Delaware Street.

HORACK, CARL W. (J) tool and machine designer, 619 Powell Street, *Portland, Ore.*

INTERSTATE IRON AND STEEL CO. (Aff.) 104 South Michigan Avenue, *Chicago, Ill.* Representatives: R. B. Dutch, Detroit, Michigan sales department; Paul Llewellyn, sales department; S. J. Llewellyn, president, and H. S. Schroeder, New York, sales department.

JAGGERS, GEORGE WASHINGTON, JR. (J) draftsman, Mercer Automobile Co., *Trenton, N. J.*, (mail) 150 Logan Avenue.

JEFFRIES, ZAY (M) research director, Aluminum Castings Co., *Cleveland, Ohio*, metallurgist, General Electric Co., Cleveland wire division, (mail) care of Aluminum Castings Co.

JENSEN, S. H. (M) mechanical engineer, Monarch Governor Co., *Detroit, Mich.*, (mail) 547 Virginia Park.

KUBLIN, GEORGE H. (M) designing engineer, Moon Motor Car Co., *St. Louis, Mo.*, (mail) 4280A Holly Avenue.

KURRASH, C. A. (M) assistant engineer, Rich Tool Co., *Chicago, Ill.*, (mail) 845 West Seventieth Street.

LANDGRAF, JACOB T. (J) mechanical engineer, Hummer Engine Works, *Jackson, Mich.*, (mail) 1024 South Jackson Street.

LEATHERMAN, E. W. (M) mechanical engineer, Goodyear Tire & Rubber Co., *Akron, Ohio*, (mail) 43 Cotter Avenue.

MCCARTY, WILLIAM F. (M) chief engineer, Defiance Machine Works, *Defiance, Ohio*, (mail) Park and Holgate avenues.

MCKINNON, R. A. (M) production manager, McKinnon Industries, Ltd., *St. Catharines, Ont., Canada.*

MAHONEY, JOHN P. (A) sales manager, Buda Co., *Harvey, Ill.*

MOISSELLE, S. WILLIAM (A) technical instructor, Hudson Motor Car Co., Detroit, Mich., (mail) Standard Motor Car Co., *Columbus, Ohio.*

MOTOR AND ACCESSORY MANUFACTURERS' ASSOCIATION (Aff.) 33 West Forty-second Street, *New York City.* Representatives: E. W. Beach, A. W. Copland, J. H. Foster, E. P. Hammond, C. W. Stiger, and G. W. Yeoman, directors.

NATIONAL ASSOCIATION OF ENGINE AND BOAT MANUFACTURERS, INC. (Aff.) 29 West Thirty-ninth Street, *New York City.* Representatives: H. R. Sutphen, president; J. J. Amory, first vice-president; P. C. Jones, second vice-president; C. A. Criqui, third vice-president; I. Hand, secretary, and J. Craig, treasurer.

NATIONAL GAS ENGINE ASSOCIATION (Aff.) Suite 1456 Monadnock Building, *Chicago, Ill.* Representatives: Walter Brown, George Cormack, O. G. Deane, F. E. McKee, J. DeForest Richards and R. K. Shriber.

NORMAN, FRANK E. (A) district sales manager, Service Motor Truck Co., Wabash, Ind., (mail) 226 Twin Peaks Boulevard, *San Francisco, Cal.*

RITCHIE, PRESCOTT C. (A) district manager, automobile equipment department, Westinghouse Electric & Mfg. Co., 2133 Conway Building, *Chicago, Ill.*

ROBERTSON, LUKE (J) layout draftsman, Service Motor Truck Co., *Wabash, Ind.*

SCHOETTLER, IRWIN (J) tool designer, Nordyke & Marmon Co., *Indianapolis, Ind.*, (mail) 817 North Penn Street.

STRYKER, CARLETON ELWOOD (J) 1217 West Fifth Street, *Los Angeles, Cal.*

TEMPLE, HERBERT A. (M) engineer, Oakland Motor Car Co., *Pontiac, Mich.*

THOMAS, CHARLES P. (M) metallurgist, Reo Motor Car Co., *Lansing, Mich.*, (mail) 1107 Lee Street.

TUNISON, BURNELL R. (M) chemical engineer, U. S. Industrial Alcohol Co., 27 William Street, *New York City.*

VACHON, L. W. (A) drawing checker, Holt Mfg. Co., Stockton, Cal., (mail) 7365 South Chicago Avenue, *Chicago, Ill.*

WHITE, A. RAYMOND (J) automotive engineer, Service Motor Truck Co., *Wabash, Ind.*, (mail) 292 West Sinclair Street.

WOOD, H. PUTNAM (M) body designer, Royal Motor Body Co., New York City, (mail) 26 Warren Avenue, *Palisade, N. J.*